WEEKLY | NEWS IDEAS INNOVATION

NewScientist

JAN 2004

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Why the sexes gang up

MOON FEVER

Mr Bush heads for space

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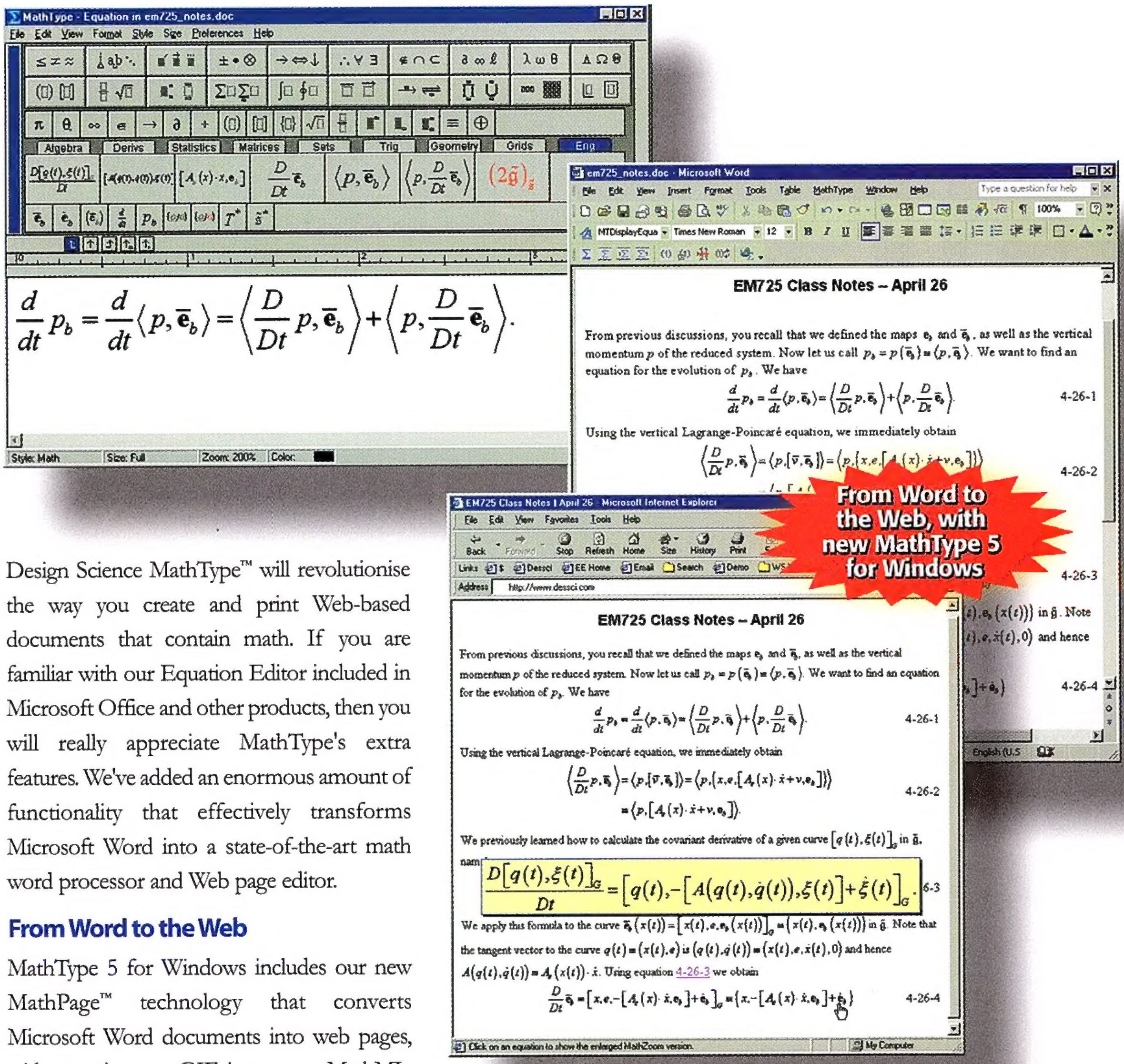

$$\frac{d}{dt}p_b=\frac{d}{dt}\langle p,\bar{\mathbf{e}}_b\rangle=\left\langle\frac{D}{Dt}p,\bar{\mathbf{e}}_b\right\rangle+\left\langle p,\frac{D}{Dt}\bar{\mathbf{e}}_b\right\rangle.$$

EM725 Class Notes – April 26

From previous discussions, you recall that we defined the maps $\mathbf{e}_b$ and $\bar{\mathbf{e}}_b$, as well as the vertical momentum p of the reduced system. Now let us call $p_b=p(\bar{\mathbf{e}}_b)=\langle p,\bar{\mathbf{e}}_b\rangle$. We want to find an equation for the evolution of p_b. We have

$$\frac{d}{dt}p_b=\frac{d}{dt}\langle p,\bar{\mathbf{e}}_b\rangle=\left\langle\frac{D}{Dt}p,\bar{\mathbf{e}}_b\right\rangle+\left\langle p,\frac{D}{Dt}\bar{\mathbf{e}}_b\right\rangle. \qquad 4\text{-}26\text{-}1$$

Using the vertical Lagrange-Poincaré equation, we immediately obtain

$$\left\langle\frac{D}{Dt}p,\bar{\mathbf{e}}_b\right\rangle=\langle p,[\bar{v},\bar{\mathbf{e}}_b]\rangle=\langle p,(x,e,[A_e(x)\cdot\dot{x}+v,\mathbf{e}_b])\rangle \qquad 4\text{-}26\text{-}2$$
$$=\langle p,[A_e(x)\cdot\dot{x}+v,\mathbf{e}_b]\rangle.$$

We previously learned how to calculate the covariant derivative of a given curve $[q(t),\xi(t)]_G$ in $\tilde{\mathfrak{g}}$, nam

$$\frac{D[q(t),\xi(t)]_G}{Dt}=\left[q(t),-\left[A(q(t),\dot{q}(t)),\xi(t)\right]+\dot{\xi}(t)\right]_G. \qquad 4\text{-}26\text{-}3$$

We apply this formula to the curve $\bar{\mathbf{e}}_b(x(t))=[x(t),e,\mathbf{e}_b(x(t))]_G=(x(t),\mathbf{e}_b(x(t)))$ in $\tilde{\mathfrak{g}}$. Note that the tangent vector to the curve $q(t)=(x(t),e)$ is $(q(t),\dot{q}(t))=(x(t),e,\dot{x}(t),0)$ and hence $A(q(t),\dot{q}(t))=A_e(x(t))\cdot\dot{x}$. Using equation 4-26-3 we obtain

$$\frac{D}{Dt}\bar{\mathbf{e}}_b=\left[x,e,-[A_e(x)\cdot\dot{x},\mathbf{e}_b]+\dot{\mathbf{e}}_b\right]_G=\left(x,-[A_e(x)\cdot\dot{x},\mathbf{e}_b]+\dot{\mathbf{e}}_b\right) \qquad 4\text{-}26\text{-}4$$

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24 January 2004

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Editorial

Bush's final frontier

Putting a human on Mars would be awesome, but is it really worth it?

MORE Republicans are against it than for it and more than half of the American public at large thinks it a waste of money. So far, George Bush's plan to send people back to the moon, and thence Mars, has won only a glum thumbs-down in the opinion polls. If the cynics are right and last week's speech really was no more than an electioneering ploy, then its vote-winning powers are already looking thin.

To be fair, a lot of Big Science projects would struggle to win support in such polls. To the wider public, building hospitals and schools will always seem a more pressing – and moral – way to use taxpayers' money than searching for, say, dark matter or the Higgs boson. But in the case of Bush's moon shot, the worries run deeper than a simple aversion to science.

Leaving aside concerns over NASA's ability to deliver (see page 16), where are the detailed cost estimates? Lunar bases and manned missions to Mars are likely to swallow hundreds of billions of dollars. Bush believes the initial costs can be met by retiring the shuttle and throwing NASA an extra billion over five years. This is very optimistic, and the agency's track record suggests that all its estimates should be treated cautiously. Each shuttle launch, for example, was supposed to cost a tenth as much as that of an expendable rocket, but its real cost was 10 times as much.

Already there is an expectation that the new plans will put other NASA space science projects at risk. Ballooning budgets will jeopardise them still more, and that is likely to mean fewer unmanned probes reporting back on the mysteries of the solar system. Is this a price worth paying? Perhaps, but before that can be judged, the proponents of manned space exploration must do a better job of explaining why we are sending people to the moon and Mars.

On the one hand, the discovery of life – or its remnants – on Mars would be worth a high price. Strangely, Bush did not mention this as a priority for the manned missions. On the other, some arguments in favour of his plan ring hollow. Enthusiasts say NASA needs a new long-term goal to compensate for the loss of Columbia, the aimlessness of the international space station and the launch of the first Chinese astronaut, which have left NASA bereaved and humiliated. But the public cannot be expected to back a vague, uncosted mission to Mars solely to give a government agency a purpose in life.

A claim with more traction is that astronauts are smarter and more flexible than machines, and so have a better chance of fixing faults and doing the right science. That said, there are few examples of space science that absolutely need humans to be present. The exception is research into the effects of hostile conditions in space on our bodies – but that is useful only if we want to send people into space. It is also easy to miss the advantages machines have over frail flesh. As the American physicist Robert Park remarked of NASA's Sojourner Mars probe: "It rambled around never complaining of the cold nights or breaking for lunch." Nor did it get radiation sickness en route or have to be brought home.

> "The public can't be expected to back a vague, uncosted mission solely to give NASA a purpose in life"

In the end, of course, the debate over whether we really need astronauts to venture into space cannot be settled without factoring in an entirely different dimension. Exploring space and gathering data are not the same thing at all. As Bush puts it: "The human thirst for knowledge ultimately cannot be satisfied by even the most vivid pictures or the most detailed measurements. We need to see and examine and touch for ourselves."

There can be no doubt that the first human steps on Mars would excite as much interest as Neil Armstrong's on the moon. So is Bush right? The answer depends on whether you think the desire to touch new worlds is an inspiring human challenge. Or whether you think the sense of purpose and progress that sending people into space offers is illusory. This is the underlying philosophical fault line in the debate, and it has as much to do with visions of human destiny as it does with science. ●

Coming next week: The moon and Mars Challenges and rewards

Upfront

CLONE CLAIMS FAIL TO IMPRESS

"THEY need to offer to the world independent confirmation of these events and developments. We, in the Scientific and Clinical World...demand that." Thus did Panayiotis Zavos of the Andrology Institute of America in Lexington, Kentucky, greet the Raelians' claim a year ago that a cloned baby had been born.

In London last Saturday, Zavos was the one trying to grab the headlines. He told reporters that his team had transferred a four-cell cloned embryo to a woman, but that it was too soon to know if she was pregnant.

Zavos claimed the embryo was created by fusing an egg from the woman with a skin cell from her infertile partner. The scientist was clearly offended by suggestions that he was no different to the Raelians, yet provided no evidence of any kind. At times his colourful, sometimes bizarre style provoked outright laughter from his sceptical audience.

Zavos would not say where the transfer took place but insisted he was breaking no laws. Most mainstream scientists regard attempts to clone humans as utterly unethical because of the high risk of abnormalities, and many think it would be unacceptable even if the technique were safe. Robert May, president of the UK's Royal Society, this week called on countries to outlaw "cowboy cloners".

PA

Panayiotis Zavos: big claim, no evidence

UK's carbon cuts

THE UK has started to deliver on its promise to lead the world in tackling global warming.

On Monday it became the first large industrial economy to announce caps on emissions of carbon dioxide by large industrial operations such as power stations, oil refineries and cement works. It fixed average reduction targets of 16 per cent by 2010.

The move will give a boost to energy companies that switch to renewable energy sources such as wind power. These companies will be able to sell spare "pollution permits" to others that cannot or will not meet the target unaided. The British government says it expects these permits to cost around £10 per tonne of carbon.

All European Union governments are supposed to submit their own industry targets by the end of March as part of the EU's plans to cut emissions by 8 per cent. EU-wide trading of carbon permits will begin next year. But Monday's announcement makes the UK the first country to lay its cards on the table.

Earlier this month the government's chief scientist, David King, said the UK was committed to cutting emissions by a further 10 per cent each decade till 2050.

'Ja' to transgenes

EUROPE'S relentless opposition to genetically modified crops is weakening further.

In a move hailed as "a great success for consumers and farmers" by German minister for consumer protection, food and agriculture, Renate Künast, the German government put forward a bill on 16 January that will allow the import, cultivation and sale of the controversial produce.

The proposal could be the start of a trend that would lead to the eventual lifting of the European Union's four-year unofficial moratorium on the approval of new GM crops. Such a move would defuse international tensions over GM foods. The US sees the moratorium as an artificial barrier to free trade, and has taken its case to the World Trade Organization.

Earlier this month, the UK edged closer to approving the cultivation of GM maize, its first modified crop. A firm decision to approve it could follow in February. The UK has also not yet decided whether to make farmers who grow GM produce liable for the consequences of any "genetic pollution" spreading to neighbouring non-GM farms and rendering their produce unsaleable. "We must address the issues of liability and coexistence of GM and non-GM crops," Elliott Morley, the UK agriculture minister, told *New Scientist*.

Germany's proposed new law covers this issue, and lays down strict rules governing the distances between fields growing GM and non-GM varieties of the same crop.

HIV trial 'useless'

AIDS researchers have launched a high-profile attack on a large US government trial of an HIV vaccine taking place in Thailand.

The fight over trials began in 2002 when both the US National Institutes of Health and the defence department were planning to go ahead with separate trials of the same combination vaccine. AIDS researcher John Moore of Cornell University in New York attacked the double trial as useless duplication. A few months later the government cancelled one of them for reasons officials said were unrelated to Moore's criticism. The NIH went ahead with plans for the trial in Thailand.

This $119 million study, which will involve 16,000 volunteers, was launched in September 2003. Now it, too, has come under fire. Moore and 21 other prominent AIDS researchers argue that new results strongly suggest the combination vaccine will not work. They say going ahead with a final or Phase III trial of a vaccine that seems certain to fail will squander money and erode public confidence in AIDS research (*Science*, vol 303, p 316).

> **"Going ahead with a trial that looks certain to fail will erode confidence in AIDS research"**

Ed Tramont of the NIH counters that the vaccine combo met every criterion leading up to the trial and underwent extensive review. He says the NIH will be publishing an official rebuttal.

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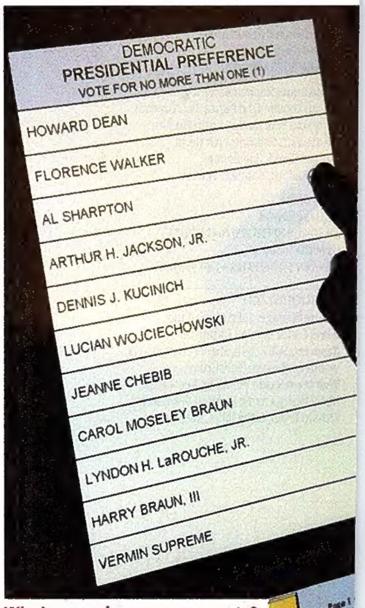

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LYNDON H. LaROUCHE, JR.
HARRY BRAUN, III
VERMIN SUPREME

Who's snooping on your e-vote?

Fusion tug of war

THE project may be all about fusion, but the six countries that have committed to ITER – the International Thermonuclear Experimental Reactor – are deeply split. A decision over whether Japan or France is to be home to the world's biggest ever nuclear fusion facility has left participants divided along political lines.

The choice was meant to be made in December. But the US and South Korea gave their support to Rokkashomura, a small seaside town in Japan, while Russia and China backed Europe's choice of Cadarache in the south of France. Political loyalties rather than scientific concerns may be dictating the decision, worries Ronald Parker, a former deputy director of ITER now at MIT. "No scientists are being consulted," he told *New Scientist*.

What's more, the French prime minister, Jean-Pierre Raffarin, suggested last week that Europe might go it alone if Cadarache loses out. "We have to have ITER, even if we do it ourselves," he said. However, a spokeswoman for the French Ministry of Research insists that all parties are still working towards a "win-win solution".

NASA/NSF

The Boomerang telescope had to wait a year to be rescued

Derring-do in the high Antarctic

ON A remote Antarctic mountain top near the infamous Pole of Inaccessibility, in bitter winds and icy temperatures comparable to those on Mars, a daring and perilous rescue mission has been successfully executed.

Who could have been stranded in such a place? Turns out it was a telescope, named Boomerang. It was built to fly above Antarctica attached to a giant weather balloon, measuring the cosmic microwave background left over from the big bang, which provides us with vital information about the structure of space-time. But on its second flight, in January 2003, this was one boomerang that didn't come back. The balloon lost altitude and was blown off-course before crash-landing 3000 metres above sea level, nose-down in the snow.

The mountain can be reached by plane, but flying there is a risky venture. Even in summer, temperatures at that altitude rarely rise above -50 °C. If the plane's engines switch off in this bitter cold, they might not restart. A US search-and-rescue team was able to land at the site a few days after the crash to recover data tapes, but scientists on the project feared the bulky telescope would be left there forever.

> "Flying there is a risky venture. If the plane's engines switch off in the bitter cold, they might not restart"

This month, however, the rescuers risked a return journey and brought Boomerang home, to the eternal gratitude of the scientists. Though it came back in pieces, the telescope could be flying again within a year. "They have been heroes," says cosmologist Paolo de Bernardis at La Sapienza University in Rome. Coming soon to a cinema near you? ●

US PONDERS E-VOTE SECURITY

ENSURING that elections for political leaders are fair and that votes stay secret is vital for any democracy. So why take the risk that it may be tampered with by hackers?

That is the question being asked this week by computer scientists and, no doubt, by citizens of California and other US states that have embraced e-voting, after it was revealed that new touch-screen voting machines have been designed to broadcast vote tallies across the airwaves.

The machines, made by Diebold Election Systems in Canton, Ohio, will accept plug-in circuits in the PCMCIA format widely used in laptop computers to allow the machines to connect to a wireless network. The company has not yet configured the machines to go wireless, but says this could be done if they are certified for use.

Transmitting votes this way would relieve officials of the task of collecting them from each individual voting terminal. But some computer experts say the system will be open to corruption. "Wireless capability is almost ideally suited for hackers," says Avi Rubin of Johns Hopkins University in Baltimore, as it means they can tamper with the machines remotely.

If certified, Diebold's machines will be used in November's presidential election. Anyone still reeling from the debacle of the hanging chads in Florida in 2000 is not likely to be reassured.

60 SECONDS

Frozen fur

Japan plans to put the first complete frozen mammoth on display in just over a year. Organisers of the Expo 2005 world exposition in Aichi prefecture signed an agreement on 16 January to excavate a woolly mammoth in Sakha, Russia. So far, only the head, tusks and left forefoot have been unearthed from the permafrost.

Cot-death rethink

Mothers should not be convicted of murdering their children solely on the basis of some experts' opinion that it is unlikely for more than one child in the same family to die of cot death (SIDS), the UK's attorney general ruled on Monday. He said supporting evidence is needed until SIDS is better understood, and ordered a review of 258 such convictions.

Hotbed of activity

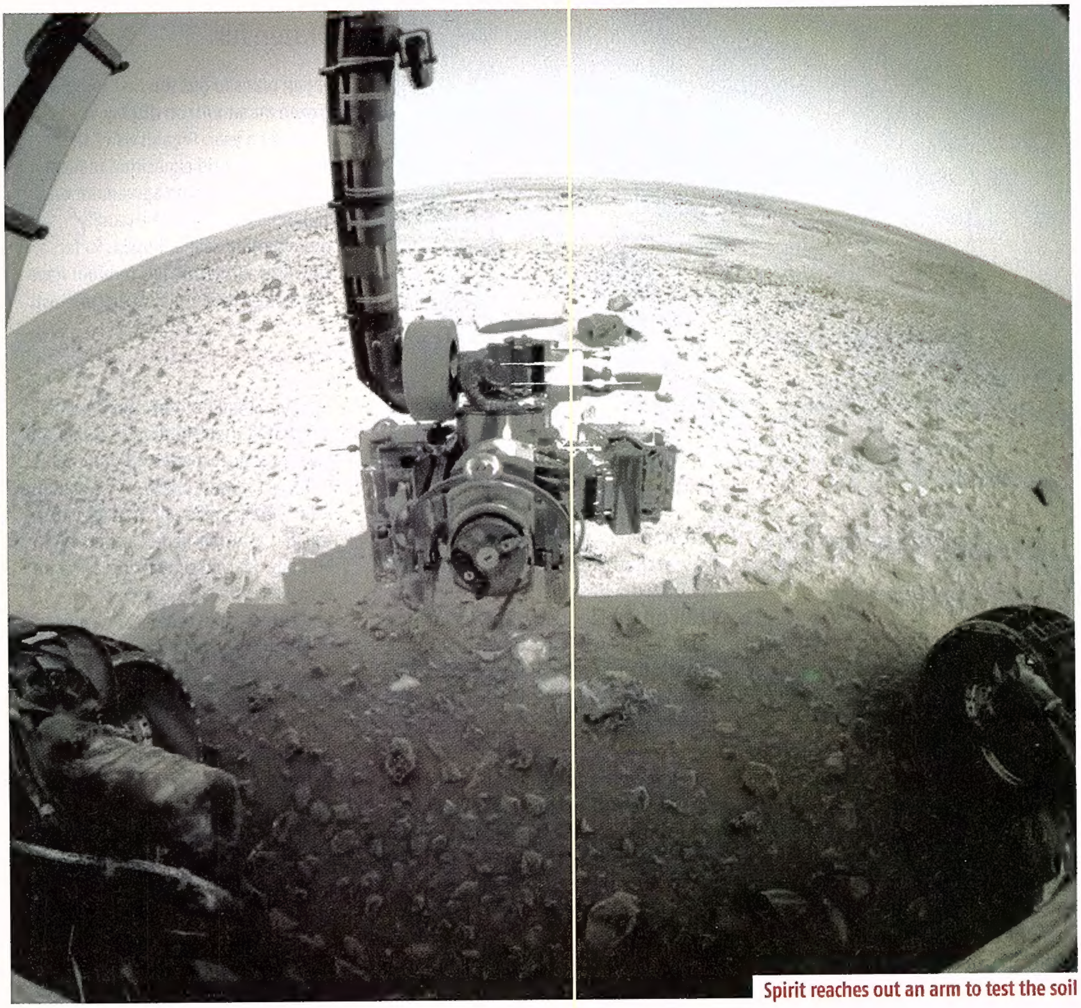
The demilitarised zone between North and South Korea could become an ecosystem preservation area. South Korean environment minister Han Myung-sook said on 13 January that she will ask North Korea to submit a joint application for a preservation order to UNESCO. The 4-kilometre-wide zone was created in 1953 and is home to over 2700 species of animals and plants.

Security catch-22

It's just as well that the US's heightened security alert over Christmas didn't presage a real biological attack. It emerged last week that tight security grounded a huge consignment of a British-made smallpox vaccine, meant to arrive in the US in December. It will now be flown out in February.

End of an era

Time has run out for Hubble. On 16 January, NASA cancelled the final service mission to the space telescope, scheduled for 2006, because of concerns over the safety of the space shuttle. Hubble was due to retire in 2010 but failing gyroscopes are likely to kill it more quickly.


JPL/NASA

Spirit reaches out an arm to test the soil

Does Mars 'mud' mean life?

Spirit's controversial images hint at liquid, salty water hiding just beneath the planet's surface

DAVID L. CHANDLER, PASADENA

HAS Spirit landed in the mud? Strange marks in the soil close to the rover's landing site have got the mission's scientists daring to consider the possibility that against all the odds, there is liquid water on – or just beneath – the surface of Mars.

If they turn out to be right, it would be the clearest sign yet that lakes and oceans once existed on the planet, increasing the chances that life did too. Intriguingly, the existence of liquid water in the soil could also rule out the only alternative explanation for the positive results that the Viking Mars landers produced when they tested for life in 1976.

The mystery stems from a small, disturbed patch of ground very close to the lander. Dubbed the "magic carpet" because of its apparent folds and ripples, the mark was made by the lander's airbags scraping across the soil. But its appearance has taken scientists analysing Spirit's images completely by surprise. Rather than breaking or cracking as you would expect completely dry soil to do, the surface seems to have flowed and folded, as if it was wet. Science team leader Steven Squyres describes the marks as bizarre. "It looks like mud, but it can't be mud," he says.

Pure water can't exist as a liquid at the low temperatures and pressures found on the surface of Mars – it would either freeze or evaporate into the painfully dry atmosphere. But that's not true of brine. If the water contains enough salt, then it could be stable. "Some dense brines are fluid down to very low temperatures," says science team member David Des Marais. He thinks that could explain the strange behaviour of the magic carpet. "If it's not pure water, brines should be considered. We know there are some brines that are stable under these conditions." Des Marais suggests that if past bodies of water on Mars evaporated, the remaining liquid would have become more and more salty until it was briny enough to be stable.

> "The surface seems to have flowed and folded, as if it was wet. It looks like mud, but it can't be mud"

The existence of some form of water within the top metre of the Martian soil, even in the equatorial regions where Spirit has landed, was one of the startling findings made last year by the Mars Odyssey orbiter (*New Scientist*, 1 March 2003, p 21). Its neutron spectrometer detected hydrogen concentrations of more than 6 per cent in some equatorial areas, which was assumed at the time to be in the form of ice or hydrated minerals.

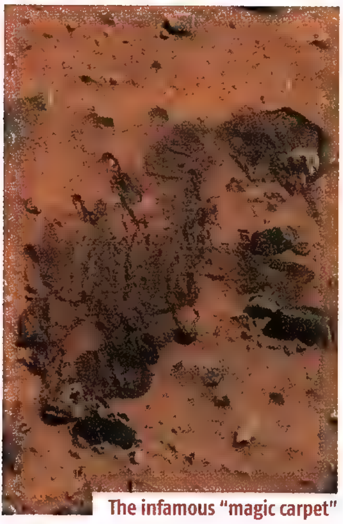
But those observations would also be consistent with brines that could, at least some of the time, be liquid. And if these briny soils were coated by even a thin veneer of dust, they would have been concealed from Mars Global Surveyor's cameras.

The Spirit team hasn't detected brine directly, and there are still other explanations for the strange markings near the lander – an electrostatic attraction between the dust grains may be causing the soil to clump together, for example.

Alternatively, perhaps ice in the soil melted on contact with the airbag, or the airbag itself might have punctured, releasing a tiny amount of moisture. But these scientists aren't the first to suggest there might be brine on the Martian surface. Others have proposed that seeping salt water created the thousands of mysterious gullies seen on

In this section

- ● Commerce threatens battle against flu, page 8
- ● Neanderthal murder mystery, page 10
- ● Colour vision comes at a price, page 12


JPL/NASA

The infamous "magic carpet"

the steep slopes of crater and canyon walls.

What's more, the very first microscope image of Mars dirt, unveiled last Friday, contains puzzling features that have also got the Spirit team thinking seriously about water. The picture shows many hollow spheres or tubes. These too could result from electrostatic clumping, but science team member and geologist John Grotzinger thinks the grains may have been cemented together by some kind of salt, perhaps when dust-coated water droplets slowly evaporated.

That is consistent with the idea that a lake dried up, leaving behind a layer of extremely concentrated brine. Grotzinger says he has seen similar hollow structures in desert soils in the south-west US, formed when capillary action draws tiny amounts of moisture up through the dust, leaving tiny tubes cemented by salts when the water evaporates.

While finding liquid water or signs of it is the central aim of the Mars Rover missions, because of its implications for past life, brine may not be good news for the possibility of life existing on the planet today, says Des Marais. "Above a certain salinity, it gets to be a problem for life."

> "Levin believes his test did detect Martian life, and says the new Mars images vindicate his view"

But any moisture in the soil, however salty, would be good news for the prospects of life according to Gilbert Levin, who designed one of the three life-detection tests on the Viking Mars missions in 1976. His "labelled release" experiment mixed Martian soil with a nutrient soup containing radioactive carbon-14. The experiments on both landers produced radioactive gas, as would be expected if alien microbes were metabolising the nutrients.

The prevailing view is that the gas was released not by living organisms but by unusually strong oxidants in the soil. But Levin believes his test did detect Martian life, and he says the new Mars images vindicate his view. "If there is liquid water in the soil, the strong oxidant cannot be there, since liquid water, or even just the vapour from it, would destroy the oxidant," he told *New Scientist*.

If the Spirit mission can prove that liquid water exists on Mars today, even in minute quantities, Levin says that rules out the alternative explanation of the Viking results, and "ineluctably leads to life on Mars".

Unfortunately Spirit will not be able to study the magic carpet area directly, because it is too close to the landing platform and so considered too dangerous for the rover to negotiate. But the team believes that whatever accounts for the behaviour of that patch of soil will be found elsewhere in the area. They hope to duplicate the marks by using one of the rover's wheels to dig into the soil, or by rotating the wheel sideways to mimic the dragging of the airbag.

Spirit could be close to an amazing discovery. But the team is being cautious until definitive proof is found. Rather than jumping to conclusions about the planet's geological past, says science team member Tim Parker, "I prefer to let Mars tell us." ●

MEANWHILE, ACROSS THE PLANET...

THE European Space Agency's Mars Express orbiter has released its first image of the Red Planet: a landscape gashed with valleys in a section of the solar system's grandest canyon, Valles Marineris.

Taken from 275 kilometres above the surface, the colour portrait shows details as small as 12 metres across in a patch of land 65 kilometres across. The island-shaped mesas, mountain ridges, and valleys in what is now dry terrain just south of the Martian equator were probably carved by ancient glaciers, says Agustin Chicarro, Mars Express project scientist. Streaks of white along the sides of ridges and mesas may be morning mist or recently exposed rocks that have slipped down the kilometre-high slopes.

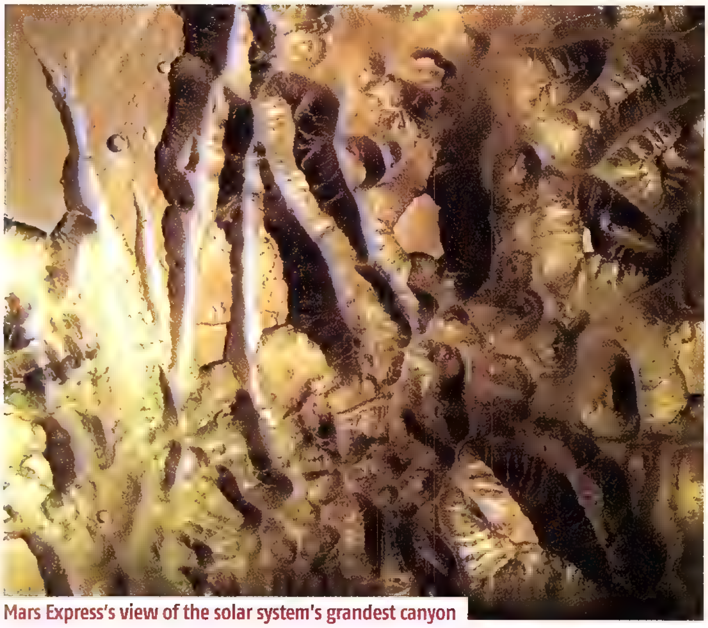
The High Resolution Stereo Camera responsible for the image has even better surprises in store, say project scientists. The camera will snap the entire planet in 3D at a resolution of 100 metres and selected regions at 2 metres. "We will have views like Spirit's, but everywhere over Mars," says Jan-Peter Muller, an astronomer at University College London.

Anticipation is also rising for Spirit's identical twin, Opportunity, which will land on the planet this weekend. All the pictures taken so far by landers on the surface of Mars look similar: rust-coloured landscapes with dark boulders, pebbles and distant hills.

But Opportunity's target site, Meridiani Planum, "will look completely different", says project scientist Matt Golombek. It should have almost none of the reddish, iron-rich dust that has dominated the sites visited so far. Instead, there should be a large amount of haematite – a dark grey iron oxide usually formed in bodies of water. Meridiani is also one of the flattest sites on the whole planet. In fact, the lack of landmarks may make it tough to work out exactly where the rover has landed.

The landing is set for Sunday morning, at 0505 GMT. Even though Spirit's touchdown worked perfectly, the team is being cautious about Opportunity. "I don't know that I'm any more confident of the second one landing than I was of the first," says Maria Zuber, a planetary scientist who helped plan the landing. She says there are still many unknowns about the temperature profile of the atmosphere at Meridiani Planum, which will crucially affect parachute deployment. This will also be the highest-altitude landing ever attempted on Mars, close to the upper limit for a safe touchdown.

Maggie McKee and David L. Chandler ●


EPA/PA

Mars Express's view of the solar system's grandest canyon

AFP/GETTY

A 15-month-old girl battling against bird flu in a Hanoi hospital

Vietnam last on vaccine list

DEBORA MACKENZIE

DRUG company contracts and intellectual property rights are impeding efforts to ensure an outbreak of bird flu in Vietnam does not result in a deadly human pandemic.

All the victims so far got the disease from poultry, but the big fear is that the virus could turn into a form capable of spreading from person to person. A flu vaccine that might help prevent this will soon become available, but instead of going to Vietnam it will be sent to rich countries to fulfil existing contracts. And researchers who have created vaccines that might save us if the bird flu does start spreading between people are unsure how to proceed without falling foul of patent rights.

Doctors have been warning for years that another flu pandemic as deadly as the 1918 one is inevitable, and many worry it could be about to happen. After an outbreak of the H5N1 strain of bird flu in poultry, Vietnam has reported 18 suspected human cases, 15 of whom have died. The World Health Organization has so far confirmed that five of the cases were caused by the H5N1 strain. Unlike previous H5N1 outbreaks, the victims are mostly children.

So far there is no sign of the bird virus spreading between people. But if someone is infected by H5N1 and a normal human flu virus at the same time, the viruses could recombine. This might give rise to a new virus able to spread among people as easily as human flu but far more deadly, partly because it would bear the bird flu's H5 and N1 surface proteins, which human immune systems have not been primed to recognise.

To prevent this, the WHO wants to give the normal flu vaccine to everyone who might come into contact with sick poultry, as has been done in past outbreaks of bird flu. The Belgian-based company Solvay, a major flu vaccine producer, is supplying the WHO with the vaccine used in the northern hemisphere this winter. But research published last week by the US Centers for Disease Control shows that this vaccine will not prevent most infections, because it is not effective against the Fujian strain now circulating.

The vaccine for the next southern hemisphere winter, which will be available in February, will protect against Fujian. But Solvay and GlaxoSmithKline have both told *New Scientist* that they must first supply the vaccine to contracted customers in countries like Australia, and are unlikely to have any left for Vietnam.

> "The companies will supply the vaccine to customers in rich countries and are unlikely to have any left for Vietnam"

If the H5N1 does start spreading between humans, a specific vaccine against it will be needed. Two labs, the National Institute for Biological Standards and Control (NIBSC) in the UK and St Jude Children's Research Hospital in Memphis, Tennessee, have each made an H5N1 vaccine virus in cell cultures which could be used to mass produce a vaccine. Neither have been tested yet against the specific H5N1 strain found in Vietnam but both protect animals against similar strains.

Standard production methods do not work for H5N1 vaccines, partly because the virus kills the chick embryos normally used to grow flu vaccine. Instead, the labs used a technique called "reverse engineering", which involves using genetic sequences called plasmids. The reverse engineering patent, however, is held by the biotech company Medimmune of Gaithersburg, Maryland, and the plasmids used are patented by various companies, all of whom will be entitled to payment if their property is used to make a commercial product. Wood says he doesn't know how the experimental vaccine can possibly be put into production quickly when there are complicated patent issues involved. "You can't sort these things out when there's a pandemic sweeping the world."

"If people felt we were facing a pandemic situation, we would waive intellectual property rights," says Jamie Lacey of Medimmune, but it is not clear whether the other patent holders would do the same. Of course, if a serious pandemic took hold, worries about patents would be swept aside. But delays in vaccine production caused by the initial uncertainty could cost many lives. Wood says there should be a clearly defined "trigger" point at which health authorities will be allowed to press ahead with plans for producing a vaccine without fear of violating patent laws. ●

SOUNDBITES

“I'd rather be fishing with my 15 grandchildren.”

Farmer and “accidental activist” **Percy Schmeiser**, who is about to go to Canada's supreme court to challenge a claim by the biotech giant Monsanto that he illegally grew its genetically modified soya (Associated Press, 19 January)

“I just thought it was a good name for my small part-time business.”

Mike Rowe of Vancouver, who has been corresponding with Microsoft's lawyers after registering the domain name MikeRoweSoft.com (ZDNet UK, 19 January)

“That's a lot by western standards, but it's normal for Russia.”

Vladimir Nuzhny of Russia's National Narcology Research Centre on experiments in which volunteers were asked to drink a third of a bottle of vodka in an hour (*The Times*, London, 19 January)

“Sadly we had to put a pet rat to sleep after it became so obese from being fed curries that it could barely move.”

Veterinary surgeon Caroline Reay of the Blue Cross animal charity, which last week warned that junk food was causing an epidemic among Britain's pets (press release, 14 January)

“Pets will not notice that they have a reduced fat content.”

A Tesco spokesperson on the supermarket chain's new range of low-fat pet food (*The Independent*, London, 19 January)

“For the third consecutive day, it has been colder here than it has been on Mars...”

The Globe and Mail, Toronto, 17 January

Early life wouldn't stand a chance in a commune

LIFE could not have arisen from an “ancestral commune” in which rudimentary life forms, not yet sophisticated enough to survive independently, pooled their metabolic talents. That is the conclusion reached by a Canadian mathematician who has analysed the interactions among such a loose-knit group of protocells.

If he is right, it undermines a leading modern view on the origin of life. In recent years, geneticists have traced the lineage of more than 30 genes all the way back to the base of the tree of life, and have found that no single origin fits all genes. This puzzling result led Carl Woese, an evolutionary biologist at the University of Illinois at Urbana-Champaign, to hypothesise that modern life arose not from a single first cell, but from several, each carrying some – but not all – of the genes needed to grow and replicate (*New Scientist*, 22 June 2002, p 10).

“There never was a universal common ancestor,” says Woese. The members of this ancestral commune would all have benefited from genes and gene products leaking out of their neighbours until eventually they evolved into self-sufficient cells.

But Peter Antonelli, a mathematician at the University of Alberta in Edmonton, Canada, has concluded that this loose-knit cooperative could not have held together. Using an arcane mathematical technique previously used by Japanese engineers to study electric motors, Antonelli wrote equations describing both the ecological interactions, such as competition for nutrients, and biochemical sharing that would have had to exist between protocells. When his colleague Solange Rutz analysed the equations, she found they were mathematically unstable, that is, the associations could not persist over time (*Nonlinear Analysis: Real World Applications*, vol 4, p 743).

“Remember the communes back in the sixties?” says Antonelli. “They didn't work, and it's the same reason. It's a loose conglomeration of individuals trying to make a stable community.” For the cooperative to work, he explains, all its members must contribute their share of the collective metabolism at the proper rate. And the more members there are, the harder it becomes to get such precise timing right. “You can't just integrate a whole lot of things all at once. It only works two at a time, and even then it's hard as hell,” he says.

> “It's a loose conglomeration of individuals trying to make a community. Sixties communes didn't work for the same reason”

If there was any sharing of genes and enzymes, he says it must have been between pairs of protocells, much as the ancestor of eukaryotic or nucleated cells assimilated a bacterium that evolved into the modern mitochondrion, though that happened much later in the evolution of life. This kind of close, pairwise association can indeed be stable, Antonelli and his colleagues found.

Reaction to Antonelli's claim has been muted. Few biologists pack the mathematical tools necessary to follow the details of his argument. Stuart Kauffman, a theoretical biologist and expert on the origin of life at the University of New Mexico in Albuquerque, says it is intuitively plausible that the bigger the “commune”, the harder it is to coordinate production rates. But he believes that such coordination could happen if the members were truly interdependent, since the whole commune would then grow at the rate of the slowest producer.

Woese points out that many modern bacterial communities contain associations of several interdependent species. This suggests there may be ways around the instability Antonelli finds in his equations. Bob Holmes, Edmonton ●

WE HEAR THAT...

ZOOLOGISTS have conducted a detailed mathematical investigation into whether any two **goldfish** swim in exactly the same way.

The international team, drawn from three cities across the US and France, filmed five fish swimming under standard conditions. They then used six **mathematical parameters** to define their swimming style, including “Lempel-Ziv complexity” which highlights irregularity in velocity, and “characteristic fractal dimension”, a measure of the fish's deviation from a straight line.

Their conclusion, which will come as a relief to pet owners who have started to wonder whether their fish have any personality at all, is that each is a paragon of individuality, cruising the tank in **its own unmistakable style**. The researchers even go so far as to conclude that the swimming styles of individual fish differ by some 99 per cent (*The Journal of Experimental Biology*, vol 207, p 697).

Team member Heike Neumeister at Yeshiva University in New York says the research could lead to a method for detecting water pollution. Even low levels of chemicals cause the fish to alter their swimming style, she says. Hopefully the technique will raise the alarm before the fish are found floating around on the surface.

Big chill killed off the Neanderthals

DOUGLAS PALMER

Our 30,000-year-old closest relative

IT IS possibly the longest-running murder mystery of them all. What, or even who, killed humankind's nearest relatives, the Neanderthals who once roamed Europe before dying out almost 30,000 years ago?

Suspects have ranged from the climate to humans themselves, and the mystery has deeply divided experts. Now 30 scientists have come together to publish the most definitive answer yet to this enigma. They say Neanderthals simply did not have the technological know-how to survive the increasingly harsh winters. And intriguingly, rather than being Neanderthal killers, the original human settlers of Europe almost suffered the same fate.

Led by Tjeerd van Andel of the University of Cambridge, a team of archaeologists, anthropologists, geologists and climate modellers have compiled a vast new set of biological, environmental and social evidence on life between 20,000 and 40,000 years ago. It includes data from sediment cores and 400 or so archaeological sites, and information gleaned from fossil bones and stone tools. To this they have added the most up-to-date climate models, and radiometric dates of human and Neanderthal sites and artefacts.

The result is a definitive series of maps covering climate change over time, the appearance of animal and plant populations, and how human and Neanderthal communities migrated with the seasons. The resolution is so good that, for the first time, researchers can reliably trace the movements of both hominid species.

Ice cores recovered from Greenland in the 1970s show that Europe's climate varied hugely during the last ice age, especially in the period between 70,000 and 20,000 years ago. Cold glacial periods were punctuated by warmer times, and the average temperature could rise and fall several degrees within a decade or so. Studies of permafrost patterns, the remains of small animals and pollen grains, as well as fossil bones, show that such changes had a dramatic effect on the flora and fauna of the time, including *Homo sapiens* and Neanderthals.

The maps show that, facing temperatures that plummeted to -10 °C in winter (see Map), Neanderthals retreated south from northern Europe 30,000 years ago, a migration which coincided exactly with the southern march of the ice sheets (*Neanderthal and Modern Humans in the European Landscape of the Last Glaciation: Archaeological Results of the Stage 3 Project*).

It is surprising "the extent to which Neanderthals seem to have been deterred by the cold, and retreated as the going got tough," says archaeologist William Davies, a co-editor of the report based at University of Southampton, UK.

The maps also reveal that the earliest modern humans, the Aurignacian people, who appeared around 40,000 years ago, could not cope with the glacial cold either. They retreated south until 25,000 years ago when they were reduced to a few refuges, such as southwest France and the shores of the Black Sea.

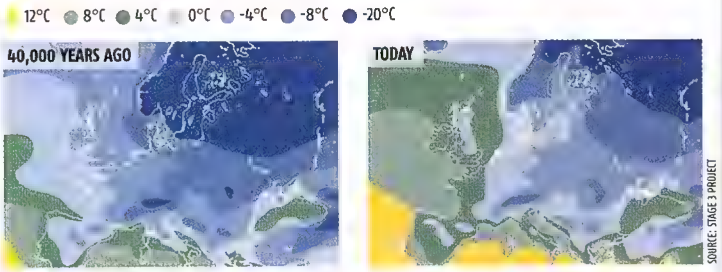
The new maps show that even at the height of the last glacial period, 18,000 to around 22,000 years ago, continental Europe supported extensive grasslands which were fodder for huge numbers of migrant animals such as reindeer and bison.

The archaeological evidence strongly suggests that both hominids coexisted in southern Europe for thousands of years, but competed for ever diminishing resources. And that might have been the end for both *Homo sapiens* and Neanderthals but for the arrival of the technologically advanced Gravettians.

The Gravettians appeared in eastern Europe 29,000 to 30,000 years ago complete with flash new tools, such as javelin-like throwing spears and fishing nets, which allowed them to catch a greater

THE LAST ICE AGE

Even during a warm phase, winter temperatures 40,000 years ago were lower than today



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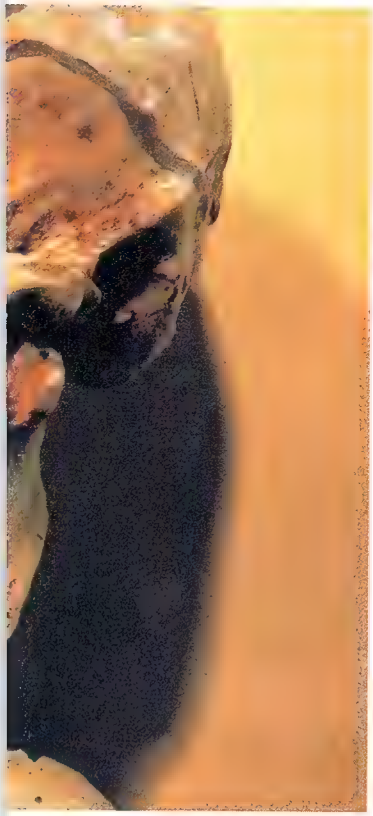


NHM

range of prey. They also had clothing to keep the cold out, such as sewn furs and woven textiles, and possibly more specialised social structures. Their ability to tough out the colder climes dominating Europe 18,000 to 25,000 years ago revitalised the human population. The Neanderthals, however, without either new blood or new technology, found it impossible to survive and died out, probably around 28,000 years ago.

For Neanderthal expert Paul Pettitt of the University of Sheffield, UK, the evidence that climate adversely affected the Aurignacian people as much as the Neanderthals is fascinating. When the going got tough in northern Europe, says Pettitt, both adopted a "get out of the kitchen strategy". In contrast, Gravettians used their technological prowess "to reorganise the way the kitchen was used". Pettitt says that step was just as revolutionary as becoming modern *Homo sapiens* in the first place. ●

Are deodorants safe?

FREQUENT underarm shaving combined with deodorant use might increase women's chances of getting breast cancer, claims a study based on a survey of over 400 women with breast cancer in the US. It is the first evidence of such a link to appear in a peer-reviewed journal, but it is far from conclusive.

Claims that deodorants cause breast cancer hit the headlines recently when Phillipa Darbre of the University of Reading in the UK published a paper reporting that preservatives used in antiperspirants and deodorants can be found in breast tumours. But this in no way proved that the preservatives, called *para*-hydroxybenzoic acids or parabens, actually caused the tumours, and most deodorants no longer contain any parabens.

The US study, by Chicago doctor Kris McGrath of Northwestern University, does suggest that deodorants or antiperspirants might be linked with breast cancer, but only together with underarm shaving. And it has too many weaknesses to be regarded as definitive.

The issue first gained publicity in the 1990s when a hoax email was widely circulated. It claimed that underarm shaving creates tiny nicks, allowing unnamed chemicals from deodorants or antiperspirants to enter the body and trigger tumours.

The first, and until now only, epidemiological study was published in 2002. Dana Mirick's team at the Fred Hutchinson Cancer Research Center in Seattle included questions on underarm shaving and deodorant use in a study comparing 800 women with breast cancer with 800 randomly chosen women of similar age. Mirick found no evidence of any link.

McGrath's study, published last month, was smaller. He divided 437 breast cancer patients into four groups depending on how often they shaved and applied deodorant. He found that the more zealous the underarm regime, the younger the women were when diagnosed with cancer. Those who shaved at least three times a week and applied deodorant at least twice a week were almost 15 years younger when diagnosed than women who did neither (*European Journal of Cancer Prevention*, vol 12, p 479). Neither shaving nor deodorant use alone was linked with a younger age of diagnosis. McGrath suspects the aluminium compounds found in many products might be to blame.

But Mirick says McGrath's study has major limitations. The most serious is the absence of a control group without breast cancer, she says. That means there could be a simple explanation for the findings: younger women use antiperspirant and shave more often than older women.

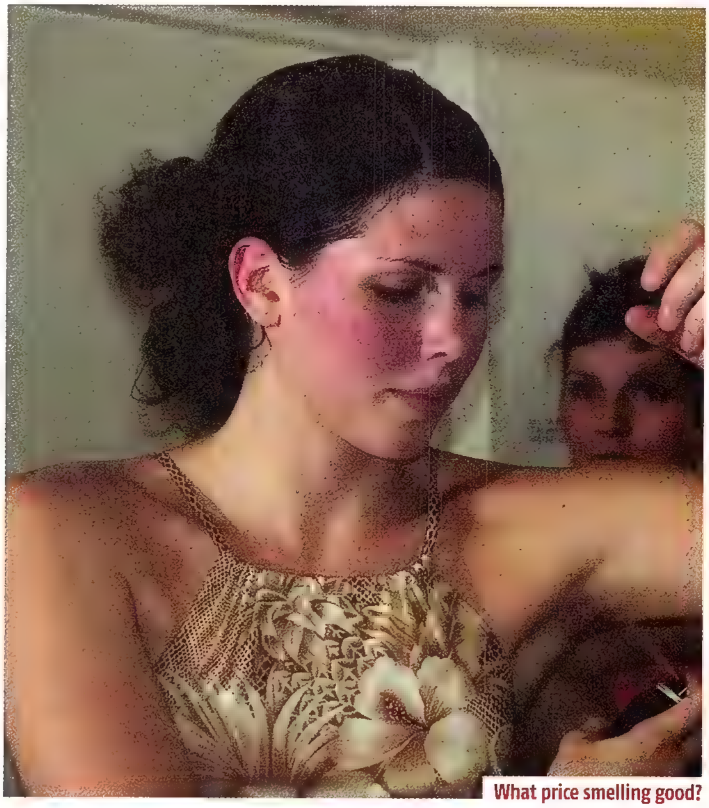
McGrath admits that the study's power is limited. But he claims it is the first to address the intensity of underarm hygiene regimes. "If a disease is from a lifestyle, those exposed to that lifestyle more should have an earlier diagnosis than those less exposed. For example, the more one consumes alcohol the sooner an alcohol-related disease should appear," McGrath says.

"It is a landmark publication because it provides the first epidemiological evidence for a link between the use of antiperspirants/deodorants and breast cancer development," claims Darbre.

Like Darbre, McGrath speculates that the steady rise in the incidence of breast cancers could be linked to deodorants. But in fact the rise in underarm deodorant use seems to parallel or even lag slightly behind the cancer rise, says David Philips of the Institute of Cancer Research in London – the opposite of what you would expect if there was a link.

Darbre cites as another cause for concern the fact that over half of breast cancers occur in the part of the breast nearest the armpit. But sceptics say this is because that quadrant has the largest amount of breast tissue.

Mirick's work has convinced most experts that there is nothing to worry about. But McGrath and Darbre argue that their studies provide enough evidence to justify funding bigger and better studies. Jo Whelan ●



SOFIA BERGLUND/PYMCA

What price smelling good?

Shattered rocks suggest ice age started in north

DATING frost-shattered rocks in Australia has pinpointed the peak of the last ice age at 22,000 years ago. The finding confirms that the ice age started in the north and spread south – some earlier ice cores had suggested otherwise.

Ice ages are driven by wobbles in the Earth's orbit that change the distribution of solar radiation the planet receives. According to the most popular theory, variations in the amount of solar radiation falling on the northern hemisphere drive climate change across the globe. But recent comparisons of ice cores from the Arctic and Antarctic suggested the opposite, that the last ice age might have started in the southern hemisphere and spread north.

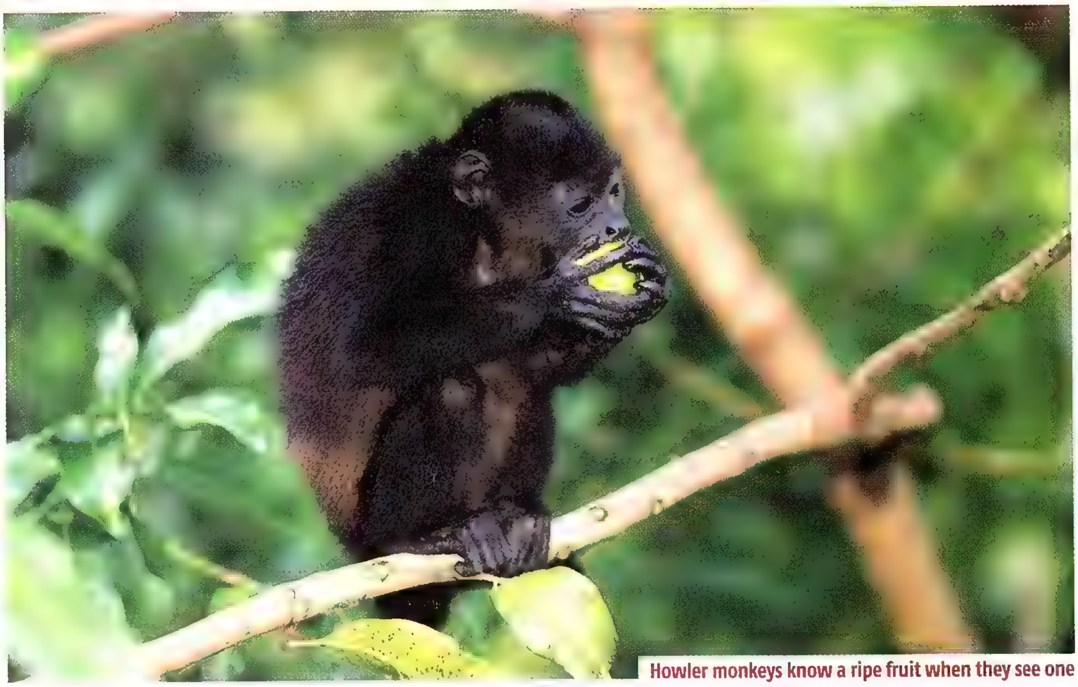
Now a study by Timothy Barrows of the Australian National University in Canberra and his colleagues suggests that the north led the way after all. To work out when rocks in eastern Australia were shattered by subzero temperatures, the team looked at isotopes in the rock that act as a marker of exposure to cosmic radiation.

Previous estimates put the peak of the ice age in Australia somewhere between 15,000 and 30,000 years ago. The new results, which will appear in *Quaternary Science Reviews*, narrow it down to 22,000 years ago. "We are confident we're within 1000 years," says Barrows.

That fits what would be expected if the ice age was triggered when solar radiation in the northern hemisphere hit a low. The next step to understanding how the cold climate spread around the globe is to date similar rock deposits in the tropics and elsewhere in the southern hemisphere, says Barrows.

Knowing the temperature at which the eastern Australian rocks shattered also led the team to conclude that the climate then was far colder than previously supposed, around 9 °C colder than today, and much drier.
Rachel Nowak, Melbourne ●

CORBIS



Howler monkeys know a ripe fruit when they see one

What we gave up for colour vision

OUR ability to see the world in glorious colour comes at a price – a diminished sense of smell. So say biologists who have found that two separate lineages of primates, one of which includes humans, independently evolved colour vision while losing much of their sense of smell.

Humans, other apes and Old World monkeys have trichromatic vision, with eyes containing three colour receptors, sensitive to blue, green and yellow-red. They allow us and our Old World relatives to distinguish around 2.3 million colours. Most other mammals only have receptors for blue and green, and can distinguish far fewer colours.

In common with other apes and Old World monkeys, humans also have a degraded sense of smell. About 60 per cent of the thousand or so mammalian olfactory receptor genes in people don't function or contribute to our sense of smell. In other apes and Old World monkeys about 30 per cent are non-functional. However, in mice and dogs, which lack trichromatic vision but have a more sensitive nose, only 20 per cent of olfactory genes don't work.

New World monkeys, though, have a better sense of smell than their Old World cousins. Only about 18 per cent of the olfactory receptor genes of most New World monkeys are non-functional. Intriguingly, these monkeys also lack trichromatic vision.

Researchers have speculated that trichromatic vision could allow primates to detect ripe fruit or young tender leaves, and could help some species recognise the coloration of their own kind or determine when a female is sexually receptive. Now Yoav Gilad and colleagues at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany and the Weizmann Institute of Science in Rehovot, Israel, present evidence that primates that evolved full colour vision became less dependent on smell.

To make the case, they measured the number of non-functional olfactory receptor genes in 18 species of ape and monkey and in people. Primates with trichromatic vision all had a significantly worse sense of smell than monkeys without.

The finding that helped clinch the case was the New World howler monkey. It's the only New World monkey with full trichromatic vision, and the researchers found that it also has the worst sense of smell among New World monkeys, with about 31 per cent of its olfactory receptor genes being nonfunctional.

This despite the fact that lineage studies show the howler monkey developed trichromatic vision independently sometime between 7 million and 16 million years ago; Old World primates developed their colour vision about 23 million years ago.

The new work doesn't prove cause and effect. But the implication is clear. The evolution of full colour vision relaxed the selective pressure to keep a full set of functional olfaction genes, making many redundant over millions of years (*PLoS Biology*, vol 2, p 1). **Kurt Kleiner** ●

Conservation plans are fatally flawed

JAMES RANDERSON

CONSERVATION managers are not taking scientific evidence into account when drawing up their plans, a survey of projects in the UK and Australia has found. Faced with species or habitats on the brink of extinction, managers are taking emergency action that may leave them as vulnerable as ever in the long term.

The need for a more rigorous approach is highlighted by an analysis of the acclaimed breeding programme that has rescued the Española tortoise in the Galapagos Islands. From just 14 individuals, the population has increased to over 800.

"It is obvious that the Española tortoise would be extinct by now [without] this programme," says Michel Milinkovitch of the Free University of Brussels (ULB) in Belgium, who has studied the revived population. But he concludes that the animals' lack of genetic diversity means they could yet be wiped out.

By 1965, hunting and habitat destruction had all but killed off the population of 3000 Española tortoises. Conservationists transferred the two remaining males and 12 females to the Charles Darwin Research Station on Santa Cruz Island as an emergency measure, and began breeding them. The first animals were reintroduced to the wild in 1975 and the colony now numbers between 800 and 1000.

But from a study of 134 of this population, Milinkovitch found that it has a genetic diversity equivalent to roughly 11 unrelated breeding individuals (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2003.2607). For a healthy population of this size the figure would typically be 300.

The diversity is so low because some of the pioneers contributed far more to the gene pool than others, Milinkovitch found. For instance, one male nicknamed Super Macho, added to the group in 1977 from San Diego zoo, sired nearly 80 of the individuals they sampled. "He really skewed the population," says team member James Gibbs from the State University of New York, Syracuse. Such low diversity means the animals are extremely vulnerable to habitat changes or disease.

"The Española tortoises' lack of genetic diversity means they could yet be wiped out"

In what the team hopes will be a textbook case of scientists and conservation managers working together, they are trying to ensure that other males get more of a look-in. They also want to encourage females who have not produced many young to breed.

But such cooperation is unusual. Most conservation managers regard genetic studies like Milinkovitch's as "obscure and academic", Gibbs says. Indeed, the World Conservation Union (IUCN) guidelines on species reintroductions do not mention how to avoid inbreeding or any problems associated with low genetic diversity.

MINDEN

Back from the brink, for now

This view is backed up by a study by Andrew Pullin at the University of Birmingham in the UK and colleagues. Pullin's team analysed 141 questionnaires filled out by conservationists at seven UK-based organisations, which asked about the scientific input that went into drawing up management plans.

Two-thirds of respondents said they had neither time nor money to look up the scientific literature, and a similar number said they hardly ever consulted anyone else when building their plans. And of 38 management plans, none included an evaluation of the scientific evidence in favour of the actions it proposed. "It's a global problem," says Pullin, whose findings will appear in a future issue of *Biological Conservation*. Research in Australia paints a similar picture, he says.

Gibbs also points out that scientists often make little effort to disseminate or explain their work to conservationists in the field, and rarely ask the questions managers want answered. ●

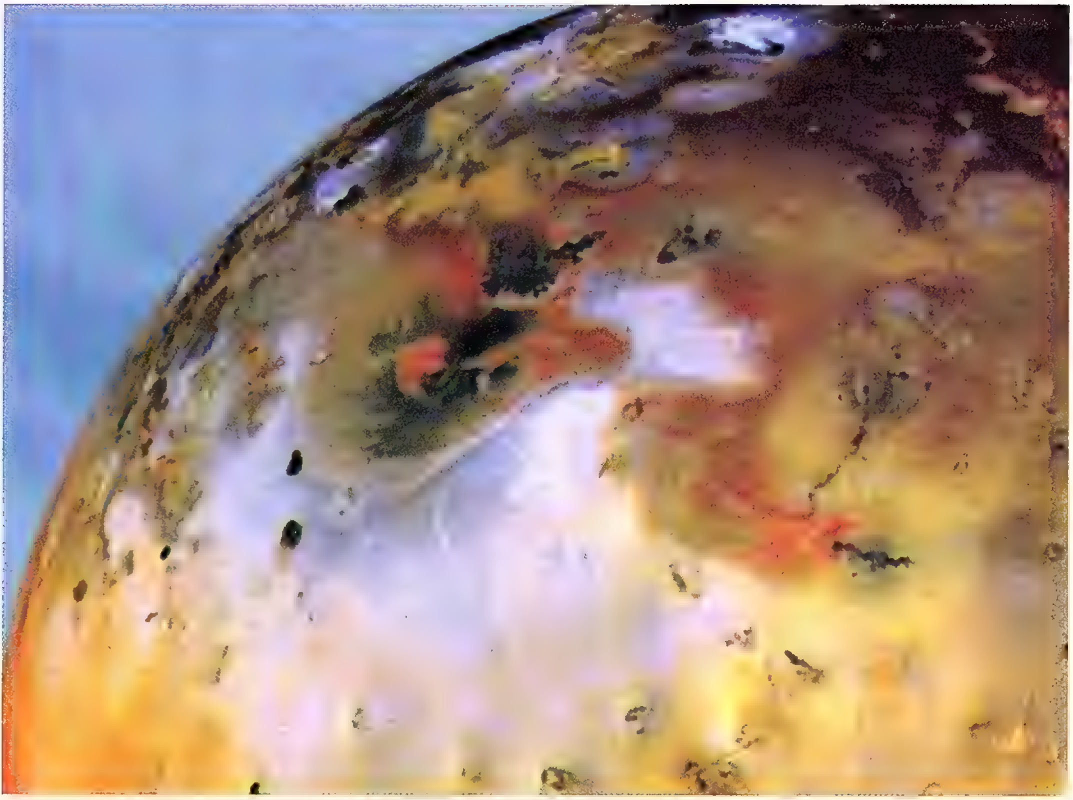
NewScientist Competition Winners

Congratulations to the following prize winners:

Rick Andre of Melbourne, Victoria, winner of the Trip to Antarctica competition [illegible] December 2004. Rick will be joining the Peregrine Voyager [illegible] for a 10 day trip to the Antarctic Peninsula and islands.

Winners of the Telstra Broadband Competition drawn [illegible] January 2004, [illegible] 12 month 1GB self install kit broadband package: (1) Ms Gillian McPherson [illegible] Anglican School, Queensland (2) Mr William Law [illegible] New South Wales (3) Dr [illegible] South Australia

In brief



NASA

Our closest look yet at violent Io's volcanic hotspots

AFTER five years of watching Jupiter's volcanic moon Io, scientists have confirmed that it is a violent place. But they were surprised to find that most of the fireworks are confined to just a few places on the moon's surface.

Paul Geissler from the US Geological Survey in Flagstaff, Arizona, and his team compared successive photos of Io, taken by the Galileo spacecraft between 1996 and 2001 as it explored Jupiter and its moons. Because there are no impact craters visible on Io, its surface must regenerate very fast, so the scientists expected to see changes all over the moon. But they report in an upcoming issue of *Icarus* that although they saw 82 separate events, including volcanic plumes, colour changes and sulphur dioxide seepage, the activity was restricted to just 17 per cent of the surface.

However, infrared measurements show that Io is losing heat elsewhere, too. Geissler concludes that its surface is also being replenished by lava quietly turning over within huge lakes, rather than by dramatic volcanic eruptions.

The scientists also found that the volcanoes on Io come in two types. Some produce relatively small eruptions that cover areas up to about 250 kilometres across with near-circular rings of sulphur dioxide, tinged yellow by silicates. But there are also a few larger plumes forming oval rings some 500 kilometres or so across.

Simple sugar slows Huntington's

FEEDING a simple sugar to mice with Huntington's disease slows brain degeneration, reports Nobuyuki Nukina's team at the RIKEN Brain Science Institute in Saitama, Japan.

The researchers fed a natural sugar called trehalose to mice genetically engineered to have a severe version of Huntington's disease. The disease is caused by mutations in the gene for the huntingtin protein. The defective protein forms clumps that kill brain cells. At 12 weeks, the treated mice had a third fewer clumps in the parts of the brain that control movement than untreated mice (*Nature Medicine*, DOI: 10.1038/nm985). They also lived about 10 per cent longer and performed better on tests of balance and coordination.

Trehalose is non-toxic and the mice drank it without any persuasion. "This is a big advantage," says Nukina. Lab tests suggest that trehalose stabilises the defective huntingtin protein. The sugar is best known for its ability to protect cells from drying or freezing, but it is not clear whether these properties are related.

At the moment doctors can only treat the symptoms of Huntington's. But other drugs have also shown promise in mice and are entering trials in people.

Amniotic boost

SWALLOWING artificial amniotic fluid might speed up bowel development in premature babies and help them cope with milk sooner.

Premature babies often have to be fed intravenously. In the womb, they would still be gulping down huge quantities of amniotic fluid. But aside from the fact it consists largely of fetal urine, not much was known about its make-up. Robert Christensen's group at the University of South Florida College of Medicine in St Petersburg has discovered that the fluid actually contains many growth factors. "It's the growth factors in amniotic fluid that helps the intestine to develop," says Christensen.

The team has developed an artificial amniotic fluid dubbed "SAFEstart" and given it to 87 babies to date. They appear to be improving more quickly, Christensen told *New Scientist*, and his team hopes to confirm the observation soon with a controlled clinical trial.

The yuck factor

DISGUST evolved to protect people from disease or harm, not just anything socially unacceptable, according to the first quantitative study of its kind.

Researchers at the London School of Hygiene and Tropical Medicine asked over 40,000 people to rate a series of paired photographs according to how disgusting they found each one. One image had suggestions of disease, such as a towel stained with what appeared to be reddish-yellow bodily fluids. Control images contained no such unsavoury suggestion, such as a towel with a blue stain. Significantly more people found the disease-related images more disgusting, according to the team led by Val Curtis.

"Disgust is a form of evasive action to protect us against signs of threat, such as disease," she says.

Sleeping on it really does help you solve a problem

A GOOD night's sleep could give you the answer you've been looking for, reports Ullrich Wagner's team at the University of Lübeck in Germany.

The researchers asked 66 volunteers to solve a series of maths problems using two simple rules. What they were not told was that there was a short cut that made it very easy to obtain the answers. After three trial runs, the volunteers were allowed an eight-hour break before continuing with the task. Of those who slept during the break, more than twice as many discovered the short cut compared with those who stayed awake (*Nature*, vol 427, p 352).

During sleep, we subconsciously sift through recent memories, which may throw up answers to problems we faced during the day, Wagner suggests. "We think the strongest explanation is that sleep acts on the patterns created during training, restructuring them to give insights to the hidden rule." Wagner thinks the best way to ensure a problem is "dealt with" during sleep might be to mull it over just before bedtime.

The team decided to investigate the phenomenon after reading many anecdotes about people waking with the solution to their problems. The Russian chemist Dmitri Mendelyev, for instance, said he devised the periodic table after he had a dream where all the elements fell down into the right positions.

P. MARLOW/MAGNUM

Ancient explosions pelt Earth with shrapnel

DEBRIS from explosions that shook our galaxy around a million years ago may be pelting our atmosphere. This might explain a mysterious "spike" in the numbers of cosmic rays bombarding Earth.

Cosmic-ray detectors in Japan and Australia have noticed an unexpectedly large number of particles with an energy of about 10^{18} electronvolts coming from the centre of our galaxy. Peter Biermann of the Max-Planck Institute for Radio Astronomy in Bonn wondered if they might come from gamma-ray bursts – powerful explosions thought to mark the violent deaths of the most massive stars in the universe.

Biermann's team calculated the likely effect of one or more gamma-ray bursts in the bustling centre of the Milky Way about a million years ago. Shock waves from the explosions would accelerate protons, which would zoom out into the galaxy and undergo a series of interactions on their journey, many of them ending up as neutrons. Biermann says the upshot on Earth today would be a shower of several thousand neutrons a year – all with energies of about 10^{18} electronvolts, matching the spike astronomers see (www.arxiv.org/abs/astro-ph/0401150).

Until now, astronomers have only observed gamma radiation and visible light from recent bursts. Studies of the cosmic rays they fling out could help explain what triggers the explosions, and also help build up a "fossil record" of gamma-ray bursts in the Milky Way long ago. "We can see the past," says Biermann.

SARS outbreak wasn't the first

THE SARS outbreak last year was not the first time the virus has infected humans. Virologists at Hong Kong University looked at 1000 blood samples taken in 2001, more than a year before the first known cases. Around 2 per cent contained antibodies to the SARS virus, they report online in *Emerging Infectious Diseases* (vol 10). But the antibodies reacted more strongly with SARS-like coronaviruses from animals than with the virus that caused last year's outbreaks.

Around 40 per cent of animal traders in Guangdong food markets also have antibodies to the virus. Different strains of the animal virus probably infect humans regularly, but do not usually cause severe symptoms or spread widely, virologists told a SARS meeting in London last week. The first confirmed SARS case this year could fall into this category: the disease was mild, no one else caught it, and the virus is genetically closer to the ones found in animals this year than the ones that threatened to cause a global outbreak last year. But continued overcrowding of animals in markets could allow another human infection to emerge. ●

NHPA

Poisonous truth of the serpent's tale

VENOMOUS snakes evolved only once 60 million years ago from primitive python-like snakes that crush their prey, according to a study of toxins from over a hundred snake species.

The finding should settle debate about how often and how recently venomous snakes evolved. Some researchers believe venomous snakes evolved several times over the aeons, along with many lineages of snakes that are supposedly non-venomous, yet cannot crush their prey.

But Bryan Fry, deputy director of the University of Melbourne's Australian Venom Research Unit, who ran the study, says almost all snakes that cannot crush prey poison it instead, and they have all evolved from the same ancient lineage. Fry reached his conclusions by using venom protein and DNA sequences to create an evolutionary tree. The results will appear in *Molecular Biology and Evolution*.

Previously, experts had assumed that snakes that lack fangs also lack venom, confusing the picture of when venom evolved. "But venom evolved before fangs, and even snakes without highly developed fangs have potent venom," says Fry.

This explains why so many "harmless" snakes have turned out on closer examination to be venomous. "They are not necessarily dangerous to humans, but they do have enough venom to settle a frog down," says Fry.

George Bush and his improbable dream

To Mars and back? Don't count on it unless a certain fumbling space agency gets a major overhaul, says **Greg Klerkx**

ROBOTS to the moon by 2008. Human moon-base builders by 2020. And what then? Doh! Mars of course. Before George Bush had even opened his lips last week we already knew what his vision would be and what the American public thought of it. An Associated Press poll, published two days previously, revealed that 55 per cent of Americans would prefer any spare cash to be spent on Earth, on things such as leaking school roofs, rather than on building homes in space.

Inevitably, the slow drip of information leaked in advance of the speech, no doubt designed to sample the reception and give time to temper the final announcement accordingly, created a more optimistic buzz in the space community. And I can see why. As a former senior manager for the SETI (Search for Extraterrestrial Intelligence) Institute and someone who has been watching the space programme for decades, I feel there is much to admire about the Bush plan in its broad outline, not least the gradual phasing out of the troubled space shuttle and a return to the original ambitions of the space age. Whatever the political motivations behind the announcement (and there are plenty), we now have a White House that is willing to put money into a daring space project.

That said, there are many questions that need to be asked. Is it scientifically worth it? Will the public and Congress swallow it? Is it technologically feasible, and on the timescale the president has set out? Passions run high on all sides. And there is another crucial question: will those on the receiving end of the cash for the project be able to deliver? In other words, can NASA handle it?

Accountants' first reaction will doubtless not be positive. Anticipating national sensitivity to more big spending in the wake of the $90 billion Iraq war and occupation, Bush isn't proposing a massive budget increase for his plan. He has doubtless been taking advice from his father: Bush senior proposed a moon/Mars plan in 1989, but when NASA returned a cost estimate of $400 to $500 billion, the project stalled on the launch pad.

Instead, Bush will ask Congress for relatively modest increases to future NASA budgets while pledging to make NASA find the rest of the cash by phasing out the space shuttle and ratcheting down US participation in the international space station (ISS), a project whose scientific relevance is shrinking as fast as its projected size. The shuttle would be retired by 2010 after it had fulfilled NASA's commitment to ISS construction. Retiring the shuttle could free up an estimated $3.5 billion annually.

So far, so good. The shuttle would be replaced by a new crew exploration vehicle (CEV), versions of which would first ferry astronauts to and from the space station and then evolve to be used for lunar and, later, Mars exploration...but it's here that things begin to look tricky. To make all of the above work, NASA and its contractor partners (almost certain to be led by Boeing and/or Lockheed) will have to design, prototype, test and then operate a completely new space vehicle in about a decade. The first manned flight of the CEV will probably be orbital or to the ISS; a lunar trip won't take off until 2015 at the earliest, and could happen as late as 2020. And if Bush's pronouncements of budget frugality are to be believed, that has to happen without any major spending increases.

Unfortunately, anyone looking at NASA's track record over the past two decades for developing new space vehicles must surely be sceptical of this timetable. Only a week after the 1986 Challenger disaster, Ronald Reagan announced a new spacecraft called the National Aerospace Plane that would "by the end of the next decade, take off from Dulles Airport [and] accelerate up to 25 times the speed of sound, attaining low-Earth orbit or flying to Tokyo within 2 hours". Eight years and roughly $2 billion later, the project was dead. In 1996, Vice-President Al Gore unveiled a prototype of a new space vehicle called the X-33, which again was to replace the shuttle. That project died in 2001, having consumed an estimated $1 billion in R&D, yet never having never flown.

"In seven years the International Space Station burnt $11 billion without a single launch"

Then, of course, there's the bumpy history of the NASA-led ISS. Reagan announced the project in 1984, saying it would be completed by 1992. Over the following seven years, it burnt through $11 billion while launching not a single piece of hardware. The station has now spanned four presidents and still isn't finished. Its budget, once tagged at $8 billion, has soared to more than 10 times that figure.

It's not a question of engineering skill and vision, it's a question of

project management. A year after Columbia, NASA's human space-flight programme is still broken. The agency has only just begun to implement the recommendations of the Columbia Accident Investigation Board, and a survey carried out within the agency at the end of 2003 indicated that not only are NASA employees scathing about the agency's leadership, they also still fear retribution for going against the company line.

This certainly doesn't sound like an organisation ready to shoot for the moon. Indeed, Apollo 17 astronaut Harrison Schmitt recently wrote that NASA ought to be massively restructured or disbanded altogether. That, in Schmitt's opinion, is probably the only way that Americans will make it back to the moon, let alone to Mars. Is the White House willing to take politically dangerous steps: closing research centres, scrapping projects and shedding jobs? If not, 2015 is going to come around far too quickly.

Even assuming the will exists to fundamentally remake NASA, other major changes are needed if a new moon/Mars programme is to stand a chance of success. NASA and its political protectors have a long track record of handing out work on human space flight projects to a just a handful of big contractors, who in turn are used to viewing these endeavours as a cash cow. The agency needs to drop its established methods and broaden its scope of partners. The burgeoning alternative space community could teach it a thing or two about doing more with less. A fine example of this is internet entrepreneur Elon Musk's company, SpaceX, which last month rolled out its first rocket, the Falcon I, with a per-launch cost of about $6 million, less than half the cost of the cheapest comparable launch vehicle. The Falcon grabbed the US Naval Research Laboratory as a customer for its first launch later this year.

And what of the world beyond American shores? While the Bush administration says it envisions international participation in its plan, NASA's international partners learned about the programme the same way as everyone else: through White House leaks and press reports. None of them was briefed on the programme before its announcement, let alone consulted about its creation. If NASA returns to human exploration of space, it cannot afford to treat the expertise of European, Japanese and other space programmes in so offhand a manner – or assume that current competitors like China can't be brought in as partners. As the ISS has shown, technological and engineering aspects of international cooperation can work superbly. It's when the political and managerial atmosphere is poisoned that cooperation begets frustration.

Predictably, Bush supporters are hailing the plan as another example of the president's intention to think big for America. Opponents just as predictably call it a diversion from a sagging economy and persistent bad news from Iraq – and an electioneering opportunity. Should the president succeed in selling the plan to Congress, the main beneficiaries would be NASA centres in three states: Texas, Florida and California, all of which are critical in this year's election. NASA's biggest human space-flight contractors, Boeing and Lockheed – among the Bush campaign's biggest contributors – also stand to gain considerably.

"Opponents of the plan call it a diversion from a sagging economy and bad news from Iraq"

If it is an electioneering move, it is a dangerous one. The fact that China recently joined the elite human space-flight club may have helped spur on Bush's plan, but if the president hopes that it will make him seem more Kennedyesque, he may find himself misled by the rosy glow that now surrounds Kennedy's vision. In 1965, with the space race well under way, a clear majority of Americans wanted space funding cut, and by 1973 the public ranked space exploration barely above foreign aid as a funding priority.

Modern America, still smarting from the loss of Columbia, might find it more than discomfiting that the president's response to this disaster is a mission of even greater complexity and cost. Since Apollo, NASA's human space flight efforts have been characterised mainly by financial and technological fumbling. Bush has set the wheels turning, but unless NASA gets a major overhaul, who knows where they will take him? ●

Greg Klerkx is the author of *Lost in Space: The fall of NASA and the dream of a new space age*, published last week by Pantheon

BUSH'S SPEECH...IN MINIATURE

"In the past 30 years, no human being has set foot on another world or ventured farther up into space than 386 miles...It is time for America to take the next steps...

Our first goal is to complete the international space station by 2010...In 2010, the space shuttle, after nearly 30 years of duty, will be retired. Our second goal is to develop and test a new spacecraft, the crew exploration vehicle, by 2008, and to conduct the first manned mission no later than 2014. Our third goal is to return to the moon by 2020...

With the experience gained on the moon, we will then be ready to take the next steps of space exploration: human missions to Mars and beyond.

We need to see and examine and touch for ourselves. And only human beings are capable of adapting to the inevitable uncertainties posed by space travel...We may discover resources on the moon or Mars that will boggle the imagination, that will test our limits to dream.

The vision I outline today is a journey, not a race. And I call on other nations to join us.

Mankind is drawn to the heavens for the same reason we were once drawn into unknown lands and across the open sea. We choose to explore space because doing so improves our lives and lifts our national spirit. So let us continue the journey. May God bless."

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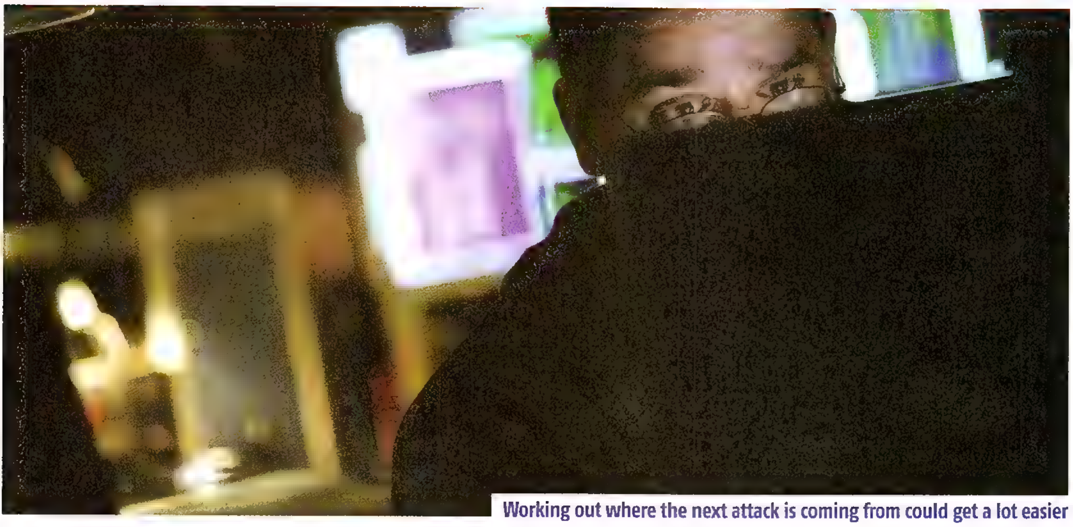
How to second-guess the next hack attack



COMSTOCK

Working out where the next attack is coming from could get a lot easier

Mutating software could beat the hackers at their own devious game

WILL KNIGHT

NOVEL computer viruses and worms can sweep the world within hours, leaving a trail of devastation, because firewalls and antiviral software work by identifying the telltale signatures of known attacks. They are useless against anything completely new.

But now software engineers at Icosystem in Cambridge, Massachusetts, have developed a program that can predict what's coming next by "evolving" future hacker and virus attacks based on information from known ones. The company is testing the technique with the help of the US Army's Computer Crimes Investigation Command in Fort Belvoir, Virginia.

The idea would be to generate these novel attack strategies centrally, then remotely update the intrusion-detection software protecting PCs and networks around the world. This would allow them to recognise attack patterns before hackers have even developed them.

The first version of the system is geared to predict hacking – though the technique is equally applicable to viruses. It works by mutating the short programs or "scripts" that hackers use to invade computers or which they plant on them for later activation. The result is artificially created hacking routines that security systems could be taught to recognise, allowing them to defend networks against previously unseen attacks.

Most attacks target well-known bugs in commercial web server software. By sending packets of data designed to exploit these flaws, an attacker can gain remote control over a computer or force it to do something self-destructive, like crashing after a certain number of keystrokes.

To defend against such attacks, today's computer networks use software that analyses traffic for signs of malicious activity. For instance, the arrival of data packets at an unusual input port may be a sign that a hacker is trying to flood a section of memory with oversized files in order to overwrite working memory and corrupt data.

But the attack may be modified in some way to confuse such defences – perhaps by combining a number of different attack routines. What's needed is an intrusion detector that can predict hackers' future strategies. And that's what Icosystem claims to have developed.

Its attack prediction system takes known hacking software and systematically mutates it to find the most deadly permutations. The mutations are kept simple so that the code still runs – there's no point in random mutations that render the software useless.

Mutations might involve renaming a file or folder created by hacker code. A small change like this could be enough to foil today's intrusion detection systems. Icosystem's software could also combine portions of different hacker programs to see any more complex attacks that evolve.

"It tries a lot of different mutations and recombinations, but they are all grammatically and syntactically correct," says Eric Bonabeau, chief information officer at Icosystem. "The idea is to continue to evolve scripts and new forms of attacks will undoubtedly emerge."

Chris Wysopal, a consultant with Boston-based computer security firm @Stake, says the approach may lead to a new, smarter generation of intrusion-detection systems. But he predicts significant performance problems if networks routinely have to search for thousands of modified scripts. "That many signatures would probably slow a detection system down considerably," he warns. ●

EVOLVING A RECORD BREAKER

The new software mimics how attack code evolves once it's released. In July 2002, a flaw in Microsoft's database program SQL Server 2000 was identified by security researcher David Litchfield of NGS Software in Sutton, Surrey, UK. Litchfield posted a few lines of code online to demonstrate how an oversized packet of data would overrun its memory buffer – providing access to a protected part of the system.

Six months later, a program that incorporated this code was released as a worm, the SQL Slammer. It included a few extra lines of code that reprogrammed a host computer to copy the worm and forward it to another computer.

Within 24 hours, this evolved code had become the fastest spreading internet worm, infecting 90 per cent of all vulnerable machines on the internet within the first 10 minutes of its release.

Magnetic trick breathes new life into MiniDisc

BARRY FOX

CAN a MiniDisc Walkman rival the iPod? Sony thinks so. After exploiting some intriguing physics to boost the storage capacity of the languishing MiniDisc audio format more than fivefold, the company thinks the technology can form the basis for a new generation of cheap digital music players, digital cameras and hand-held movie viewers.

Launched in 1992, a conventional MiniDisc (MD) records an hour of music or speech on a 177-megabyte 6.5-centimetre disc. But although MD has been a big success in Japan, it has been overshadowed elsewhere by recordable CDs. But with its capacity now expanded to 1 gigabyte per disc, Sony thinks it will be a viable alternative to digital music players like Apple's iPod.

The cheapest iPod stores 1000 tracks on a 4-gigabyte hard drive and costs $249. But Sony predicts the cheaper Hi-MD player it intends to launch will store several hundred tracks on a new 6.5-centimetre disc. Anyone who wants more tracks simply slots in a different disc – and these are likely to cost a dollar or two at most.

Alternatively, Sony says the new 1-gigabyte discs can hold over 6000 high-quality still photos, or five two-hour movies compressed to the MPEG4 standard – a capacity that could lead to Hi-MD-based digital cameras, or hand-held viewers for displaying movies.

TOSHIFUMI KITAMURA / GETTY

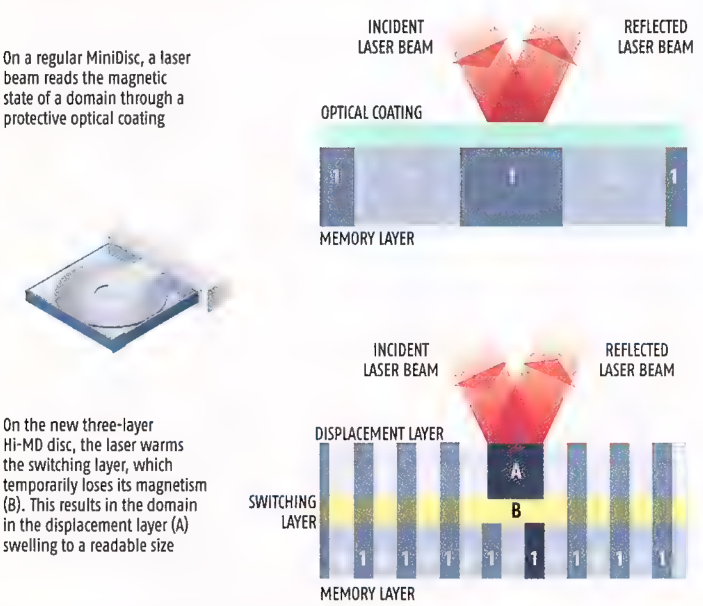
Same size, five times as much music

How did Sony manage to quintuple the MD's capacity? When the system was unveiled at the Consumer Electronics Show in Las Vegas two weeks ago, the company refused to explain the technology. But *New Scientist* has found the relevant patents and can reveal how it works.

Unlike CD and DVD, which are all-optical, an MD records data magnetically, while a laser then reads it optically. To record, it heats a spot of a ferromagnetic material with an infrared laser pulse that briefly raises its temperature above the material's Curie point – the temperature at which it loses its existing magnetism. Then, as it cools, it becomes imprinted with a magnetic field that is focused on it by a nearby magnetic recording head. The recording is read by

MAXIMISING THE MINIDISC

Sony's patented technique allows a long-wavelength infrared laser to read the state of the small magnetic domains needed to cram in five times as much data as a conventional MiniDisc



On a regular MiniDisc, a laser beam reads the magnetic state of a domain through a protective optical coating

On the new three-layer Hi-MD disc, the laser warms the switching layer, which temporarily loses its magnetism (B). This results in the domain in the displacement layer (A) swelling to a readable size

CUTTING EDGE

IN VINO VERITAS

Choosing the materials that make hi-fi speakers sound groovy has always involved a mixture of acoustic science and plain old trial and error.

Wood vibrates evenly – which is what makes stringed instruments and woodwind sound so good – but ultra-thin loudspeaker cones made of wood always dry out and crack.

Now, after lengthy research, JVC in Japan has solved the problem by marinating the wood in sake (rice wine) to make it malleable. It is then pressure-moulded into a cone, infused with thermosetting resin, moulded and finally heated to harden the resin.

The first speakers with the wooden cones will go on sale in the US in May. Hi-fi fans are already saying the prototypes sound great. JVC isn't saying what experiments with cheap sake led to the discovery.

WI-FI HITS THE ROAD

It's certainly a novel approach to curing road rage. Researchers in Sweden are trying to create a sense of community between frustrated drivers stuck in endless traffic jams by providing them with a mobile Wi-Fi network that lets drivers browse and listen to each other's music. Called Sound Pryer, the system is the brainchild of Mattias Östergren and colleagues at the Interactive Institute in Karlavägen, Sweden.

The idea is that digital tracks stored on a hand-held Wi-Fi computer mounted on the dashboard are streamed onto the airwaves and picked up by nearby cars within range of its Wi-Fi transmitter. Drivers can browse other motorists' playlists and download a tune.

"For traffic jams it's an ideal activity," says Östergren. There is just one problem: if drivers fail to log off the wireless net as the traffic jam clears, their music will be interrupted with snippets of every song that comes within range.

FILTERING ARSENIC IN A FLASH

A novel form of aluminium oxide (alumina) is being developed to remove the arsenic that pollutes well water in Bangladesh. Jongheop Yi at Seoul National University in South Korea says ordinary alumina is less effective at doing this because of its irregular pore size and lack of interconnectivity between pores. To overcome this he has developed a form he calls mesoporous alumina (MA), which has bigger, interlinked pores. In two hours, MA removes seven times as much arsenic as activated alumina can in two days, he reports.

switching the laser to a lower power, so that it does not heat the coating past its Curie point, and optically sensing the effect each spot has on the reflection of polarised light.

On a Hi-MD disc, the magnetic domains are five times smaller than on an ordinary MD, allowing it to record five times as much data. These domains are too small to be read by the infrared wavelengths used in MD players, because the beam simply cannot focus tightly enough to read them, yet the wavelength cannot be changed because Sony wants the Hi-MD players to be able to play old MD discs.

Sony has come up with a clever trick to resolve this dilemma. By employing three magnetic layers instead of one, it has devised a way to temporarily swell the shrunken domains to a readable size (see Graphic). On top of the standard magnetic layer, a Hi-MD disc has a "switching" layer, with a "displacement" layer on top of that. When a domain isn't being read, the magnetic field in the memory layer is coupled right through the switching and displacement layers.

Crucially, the middle switching layer is made from a magnetic material that has a lower Curie point than the layer above. When the read-out laser heats the disc, the spot on the switching layer beneath the laser loses its magnetic properties, so it is no longer coupled to the displacement layer above. This weakens the "magnetic fence" around the domain in the displacement layer so it temporarily swells to a readable size for a brief moment as the laser passes. Sony's patents do not identify the materials that do this.

Sony plans to launch the Hi-MD players in the spring, alongside an online music downloading service. Today's MD recorders sell for under $100, with blank discs at $1. While Sony has not yet announced the price of its new players and discs, it's hinting that they will be far cheaper than most digital music players. ●

Endoscope goes where none has gone before

COCHLEAR implants designed to restore hearing to deaf patients cannot always be fitted because of unexpected obstructions in the inner ear. But a new endoscope, made of a single optical fibre just half a millimetre wide, could one day let doctors see these obstructions and guide the implant around them. It could also be used to peer inside other narrow structures such as blood vessels.

Cochlear implants convert sound into electrical signals, which are used to stimulate the auditory nerve fibres in the cochlea of the inner ear. To fit the implant, an array of electrodes is fed down the cochlea around one and a half turns of its coiled, shell-like structure. Surgeons do this work "by feel" – and if they hit an obstacle the operation has to be abandoned. "In roughly 10 per cent of cases you have an obstruction," says Halit Sanli, a biomedical engineer at the Sydney Cochlear Implant Centre in Australia.

What they really need is a miniature endoscope that would allow them to see around the obstruction. Standard endoscopes are too big: they comprise bundles of thousands of optical fibres and are about 5 millimetres wide.

So a team of photonics experts led by Martijn van Eijkelenborg of the Australian Photonics Cooperative Research Centre at the University of Sydney turned to "holey fibres", a technology that could provide critical connectors in the optical computers of the future. These are single fibres with microscopic holes running right through them, like the lettering in a stick of seaside rock. Light is channelled down each hole, only emerging when it reaches the end of the fibre.

Because the light entering each hole remains separate from light in all the other holes, the pattern of light leaving the fibre at the other end creates a discernible image. The plastic between the holes also guides the light in the same way as the holes themselves, effectively doubling the number of light channels.

Van Eijkelenborg and his colleagues made the endoscope by drilling 112 holes into an 8-centimetre-thick plastic rod, stretching it until the fibre was just 0.5 millimetres wide. This creates an image consisting of 224 pixels. A beam splitter ensures light sent down the fibre to illuminate the interior of the cochlea does not interfere with the image coming the other way.

The image is "a pretty crude one", says van Eijkelenborg, who now hopes to boost the low resolution by creating fibres with up to 1000 holes before beginning full-scale development of the instrument for medical uses.

Rachel Nowak, Melbourne ●

SPL

Conventional scopes are too thick for imaging narrow tubes

INVENTION

ENIGMATIC BANKNOTES

Today's high-resolution image scanners and colour printers are making it easier to create realistic forgeries of bank notes, cheques or share certificates. Now Swiss company Kbagiori has filed a patent application on a simple way to make fakes easier to spot (WO 03/099579). Instead of printing two unrelated serial numbers on each bank note, the second number is calculated from the first using a secret cipher. So unless would-be forgers obtain the cipher, they will not be able to work out what the second number should be, and any fakes will have pairs of numbers that don't tally. For added security, the second number could be printed in an ink that can only be seen under UV light.

ATOMIC HAMMER FLATTENS MIRRORS

Space telescopes need ultra-flat mirrors to make sure they provide undistorted images. The problem is that polishing can remove too much surface material from the mirror.

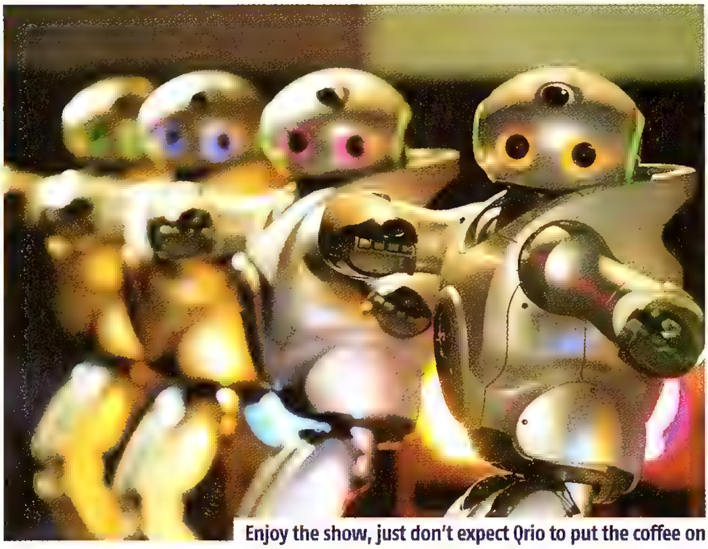
Two US inventors, Jacques Kools of California and Adrian Devasahayam of New York, have a solution (US 2003/0224620). An inert gas, such as argon, is ionised and fired as a low-energy beam towards the surface of a copper mirror in a vacuum. By carefully controlling the beam's energy and making sure it hits the surface head on, the pair have found they can physically "hammer" the surface atoms flat without etching away the coating.

SOUND APPROACH TO BIOTECH

Biotech labs detect the activity of antibodies by labelling them with fluorescent chemicals that glow when the antibody binds to an antigen. But the marker can alter the behaviour of the molecules under study, so Autonomics APS of Copenhagen suggests a sound alternative (WO 03/100413). The test materials are placed on a flat surface between a piezoelectric sound generator and a detector. As the sound waves travel through the test materials, any larger molecules formed when antibodies bind to antigens create a telltale shift in the waves' frequency. Barry Fox

Four wheels good, two legs bad

Walking robots may be great fun, but they're not much use around the house, says **Duncan Graham-Rowe**



Enjoy the show, just don't expect Qrio to put the coffee on

YOSHIKAZU TSUNO/GETTY

WHEN Sony last month unveiled Qrio, a diminutive two-legged robot that can run like a human, it seemed like yet another breakthrough in a sequence of such advances in robotics. Only last year, a troupe of similar Sony biped robots performed a choreographed dance routine. And two years before that, Honda showed off a humanoid biped that walked with a confident swagger.

But while it is highly entertaining to see these robots doing their stuff, most robotics experts say Sony and Honda's technology is little more than a red herring. They say walking and running are probably the least efficient, most power-draining ways for robots to get around – especially in the home. As a result, it's going to take decades before we see humanoid biped robots traipsing around our houses carrying piles of washing or putting up shelves.

Hollywood and sci-fi authors have created a distorted image of what a useful robot should look like. Think C3PO and the Terminator. When asked to picture a robot, most people immediately describe a humanoid robot, says Ben Krupp of MIT spin-off Yobotics in Cincinatti, Ohio. "It's a dream. We want to see something walking around the house that looks like us," he says.

So why are blue-chip corporations like Sony and Honda, with interests in audio-visual consumer electronics and vehicle manufacturing respectively, investing so many tens of millions of yen in furthering biped robotics, a seemingly irrelevant field?

Sony describes its robots as "corporate ambassadors". Meanwhile, Honda says its aim is to harness technology "to improve the lives" of its customers. But critics say the truth is that they have been seduced by science fiction.

"They're doing this because it's fun. Sony is in the entertainment business," says Colin Angle, a founder of iRobot Corp in Boston, Massachusetts, which last year launched the Roomba, a robotic vacuum cleaner.

Robotics experts used to argue that if we were ever to have a single multi-purpose droid – complete, of course, with bow tie and a butler's voice – it would need to have two legs to operate in the human-built environment. Two legs, it was thought, would get your robot to places that wheels could not, such as up and down stairs and high shelves.

But that idea is history, roboticists now say. Legs are no longer necessary. Tracked robots can handle stairs at more than useful speeds, and even if it were possible to program a robot to do all your chores, says Angle, you don't need legs to clean a house or keep an elderly person company.

"Legs decrease function, increase price and decrease reliability," he says. For example, it is much easier for a wheeled or tracked robot to carry a load than it is for a legged one. A biped needs continually to adjust the forces required to stay balanced, since its centre of gravity shifts with the tiniest additional load (see "A question of balance"). This is an enormous power drain. In addition, the motors are in constant use, even during moments of stability, resulting greater wear on their parts.

Power is the big issue, says Krupp, because battery technology isn't up to the task of operating a robot for 24 hours without a recharge. Legs are simply too inefficient.

Even if Qrio could run about for longer than 30 minutes before conking out, there are many control aspects of walking that have yet to be solved. As impressive as they are to watch, the 60-centimetre high Qrio and Honda's walker, Asimo, which is twice as tall, can only move on relatively even surfaces and have only a limited ability to adapt to changes in them. A kid's toy on the floor could trip them up.

Angle puts the obsession with bipeds down to simple "sex appeal". Walking is both an attractive and challenging way for Sony and Honda to parade their own techno-supremacy, hoping to give the impression that extreme high-tech will trickle down to their bread-and-butter businesses.

Honda says it recognises that the technology isn't there yet. But ultimately it believes it can solve the power problem, and is aiming to create a useful multi-purpose android within the next 15 years. Meanwhile, the rest of the robotics industry will get on with designing more practical machines. ●

A QUESTION OF BALANCE

Despite the criticism from the robotics community, advances are being made in bipedal locomotion. Most two-legged robots use balancing software that follows a routine called Zero Moment Point (ZMP) calculation, which works out the forces and positions needed to keep a robot stable at all times.

But for ZMP to work the robot must be in contact with the ground at all times. Qrio's advance is that when running, both its feet can lose contact with the ground without compromising stability, says Ken'ichiro Nagasaka of Sony's robotics division. And whereas walking involves constant control to maintain balance, running is in principle simpler to maintain because the robot's greater forward momentum helps to keep it stable.

In the US, Hugh Herr, director of the Leg Lab at MIT in Boston, says his colleagues have just worked out a way to let a running robot cope with uneven surfaces. They have found that ensuring the leg is moving backwards as it touches the ground vastly improves stability.

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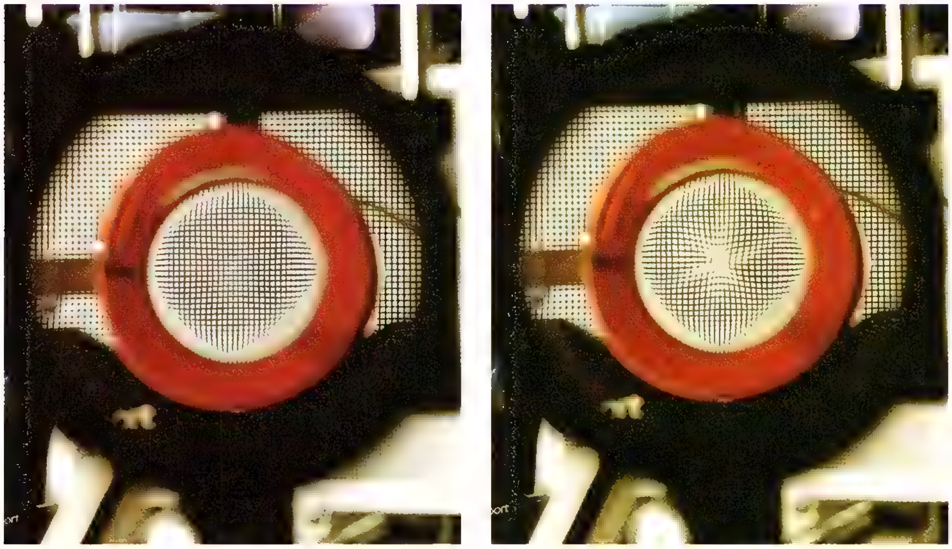


They look like simple slabs of rubber or plastic. Yet they bend light like a lens – and change their focus at the flick of a switch. **Jeff Hecht** investigates a new kind of optics, and why the Pentagon is so interested

THE lens in Ed Rietman's lab looks like something a basement inventor put together at home. It consists of a circular slab of transparent rubber a little smaller than a jam-jar lid, held in an aluminium frame. Light seems to pass through it in just the same way as through any other transparent material. And the view through the lens is nothing special, just a power cable on the other side of the office. It is hard to believe that something so modest-looking could change optics for ever.

But when Rietman switches on the power to his lens, something strange happens. The flat slab of rubber doesn't move, change shape or rotate as a more conventional lens might, but the view through it changes dramatically. Suddenly, the cable on the other side of the room shrinks. When Rietman turns off the power, the view returns to normal. Not only is his rubber slab acting as a lens, it is also changing its power.

Rietman's work is one of a number of projects commissioned by the US Defense Advanced Projects Research Agency aimed at developing a revolutionary new family of lenses. The programme is the brainchild of Len Buckley, a chemist from the Naval Research Laboratory in Washington DC. The lenses Buckley is aiming for could change everything from high-powered telescopes and military guidance systems to cheap disposable cameras.

"If you look at what's been done with lenses over the past several hundred years, it hasn't changed very much," Buckley says. As he prepared to join DARPA in early 2002, Buckley began to think about ways to move on from this medieval technology. DARPA asks incoming project managers to plan fresh approaches to important technical problems, and Buckley decided to tackle the complexity of modern optical systems.

Periscopes, viewfinders, telescopes and camera lenses are made up of many individual optical components. They are masterpieces of ingenuity, but they are also cumbersome and delicate. Zoom lenses in particular can be extremely unwieldy compared to the size of the camera. Designers have wrestled for decades over the problem of how to reduce this complexity and bulk while maintaining high performance. But Buckley has a new approach that he hopes will change everything.

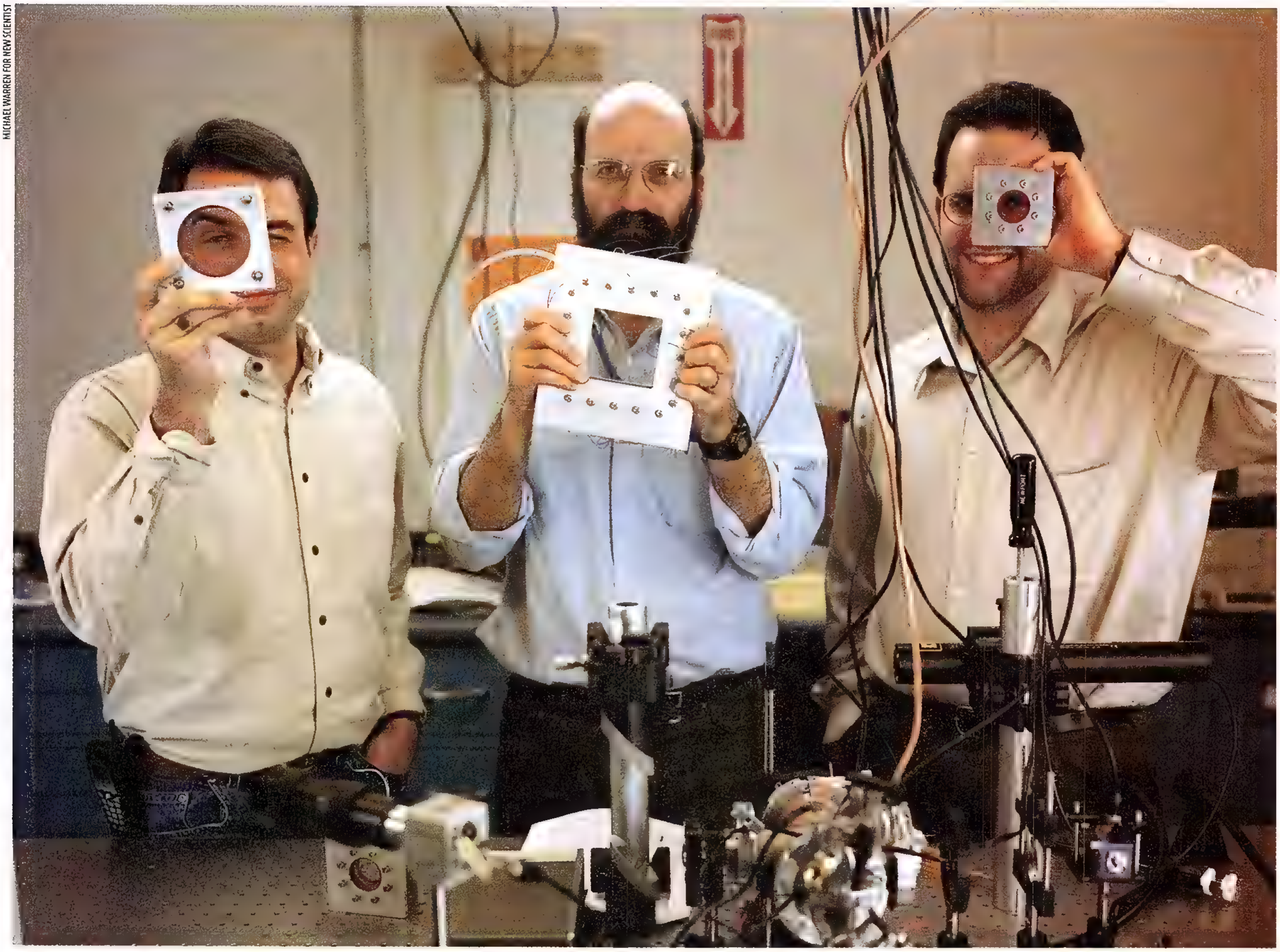
The key property of any material used to make lenses – apart, of course, from its transparency – is the ability to bend light. The strength of this bending effect is summed up in a parameter known as its refractive index, which is essentially a measure of how much more slowly light moves through the material compared with its speed in a vacuum. For example, the glass used in conventional camera lenses is said to have a refractive index of 1.5, because light travels 1.5 times as fast in a vacuum as it does in the glass.

It is the change in speed as a light ray crosses the boundary between one material and another that causes its path to bend. The amount by which the ray bends depends on the angle at which it crosses the boundary, so the optical behaviour of a conventional lens is fixed by its shape. If a lens is convex, meaning thicker at the middle than at the sides, parallel light rays are bent so that they come together, like sunlight focused by a magnifying glass. If the lens is concave, or thicker at the sides, the light rays are spread apart.

In modern cameras, images are projected onto photographic film or electronic imaging chips by assembling two or more lenses and moving them back and forth to keep the image in focus. The limit to how much a lens or system of lenses can be moved in a camera or microscope restricts the range of distances an optical system can cope with. It can be extended with extra lenses and clever design, and part of the lens designer's art is to balance this complexity against cost and practicality.

But Buckley knew another way. The human eye has only one lens, yet it does a superb job of focusing on objects over a range of distances.

Mike Costolo, Ed Rietman and Keith Higginson of Triton Systems are banking on lenses that change focus electronically to be the next generation of optics (right)



MICHAEL WARREN FOR NEW SCIENTIST

Instead of moving, the eye's lens focuses by changing its shape. Turn from this page to look far away, and the lens of your eye becomes thinner and flatter to keep the image in focus. Turn your gaze back to the page, and your lens becomes rounder and fatter again.

This got Buckley thinking about another way of changing the power of a lens: not by changing its shape, but by changing the refractive index at different distances throughout the lens. Buckley knew that in some materials, such as certain silicones, the refractive index can be changed, just slightly, by passing ultrasonic pressure waves through them. As the waves interact with the material, they push atoms together then pull them apart, making the material alternately denser and less dense. This produces a moving pattern of alternating zones of high and low refractive index as the waves pass through the material.

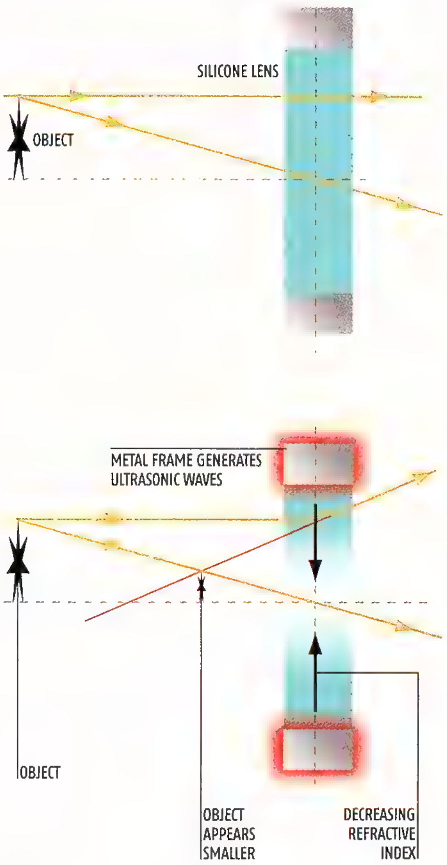
The ability of ultrasonic waves in solids to modulate a beam of light and make it flicker has been known for decades, but it had never been used in focusing. Rietman and his colleagues Keith Higginson and Mike Costolo at the company Triton Systems in Chelmsford, Massachusetts, have been commissioned by Buckley to how work out to exploit this effect to bring light to a focus and so create a useful lens.

The frame around the silicone rubber disc is the key. It houses a set of piezoelectric actuators that generate high-frequency ultrasonic waves. Waves generated by each actuator reflect back and forth across the frame, setting up an interference pattern. The patterns from each actuator cross in the middle of the lens, and by tweaking the frequency of the actuators it is possible to produce a static interference pattern that makes the centre of the silicone disc less dense than the edges, thereby lowering its refractive index. The result is that the refractive index of the silicone increases further from the centre, so light rays that strike it spread out . As the eye traces the rays back, the object appears smaller and further away.

There is, however, a long way to go before the rubber lens can be put to practical use. So far, only an area a few millimetres across at the very centre of the lens shows any change in refractive index. Increasing the wavelength of the ultrasound would extend the area, and Rietman's team is currently trying to build actuators that are powerful enough at these wavelengths. They are also working on liquid lenses. He and Higginson show off a 7-centimetre glycerine lens between two ▶

VARIABLE LENS

A lens made from a slab of silicone rubber can change the apparent size of a distant object without the lens itself having to move at all. The key is to use a material with a variable refractive index


SILICONE LENS
OBJECT
METAL FRAME GENERATES ULTRASONIC WAVES
OBJECT
OBJECT APPEARS SMALLER
DECREASING REFRACTIVE INDEX

glass plates. The refractive index change is smaller than in the rubber lens, so they make it visible by turning down the lights and aiming a green laser beam through the centre. The beam spreads to a blur on a screen 1.5 metres away until they switch on the power and the blur becomes a bright spot.

To make these into useful lenses, the team will eventually have to overcome one big hurdle – chromatic aberration, which also blights conventional lenses. Simple materials like glass bend light of different colours by different amounts: blue light more than red light, for example. This is what makes a prism separate white light into its component colours. But in a simple lens it means that different colours are brought to a focus at slightly different points, causing coloured fringes around objects in cheap telescopes and fuzzy images in cheap cameras.

Lens designers can get around this problem because different types of glass disperse colours to a different extent. For example, flint glass has about twice the dispersive power of crown glass. So by combining a convex flint lens with a concave crown lens, the dispersive effects can be made to more or less cancel out. But this comes at the price of vastly increasing the complexity of devices such as telescopes and camera lenses.

The human eye has a very different solution to the problem of chromatic aberration. Instead of using numerous lenses made of different materials, the eye's lens is made up of between 2000 and 3000 layers of cells stacked on top of each other. Some layers are thicker than others and have different refractive and dispersive properties, and they are arranged in just the right way to cut out chromatic aberration. Buckley believes that this might point the way to other methods of minimising chromatic aberration, and is funding research into materials inspired by the best features of natural lenses. "We can't use the materials nature has because they're not very robust," he says. But there are artificial nanostructures that may be able to compensate for chromatic aberration in a different way. One idea is to fill the pores in a porous material with certain optical properties with a second material that has different optical properties.

Sterling McBride of the Sarnoff Corporation in Princeton, New Jersey, is working on moving transparent fluids inside regularly structured materials known as photonic crystals. As the fluid moves into the pores, it changes the overall refractive index. McBride has changed the focal length of an experimental lens by a factor of 2 in this way, meaning that the distance to the lens' image doubled, without the lens or object having to move. The system acts only on infrared light, but it is promising for the infrared wavelengths in military night-vision systems, McBride says.

Another related approach is the work Buckley has commissioned from Shin-Tson Wu at the University of Florida in Orlando. Wu is working with liquid crystals, which are made up of cigar-shaped molecules that tend to align themselves with an electric field. Light travelling in the direction of the long axis of the molecules experiences a different refractive index than light shining across the long axis. Wu can vary the strength of the field to change the refractive index of the material as more molecules become aligned.

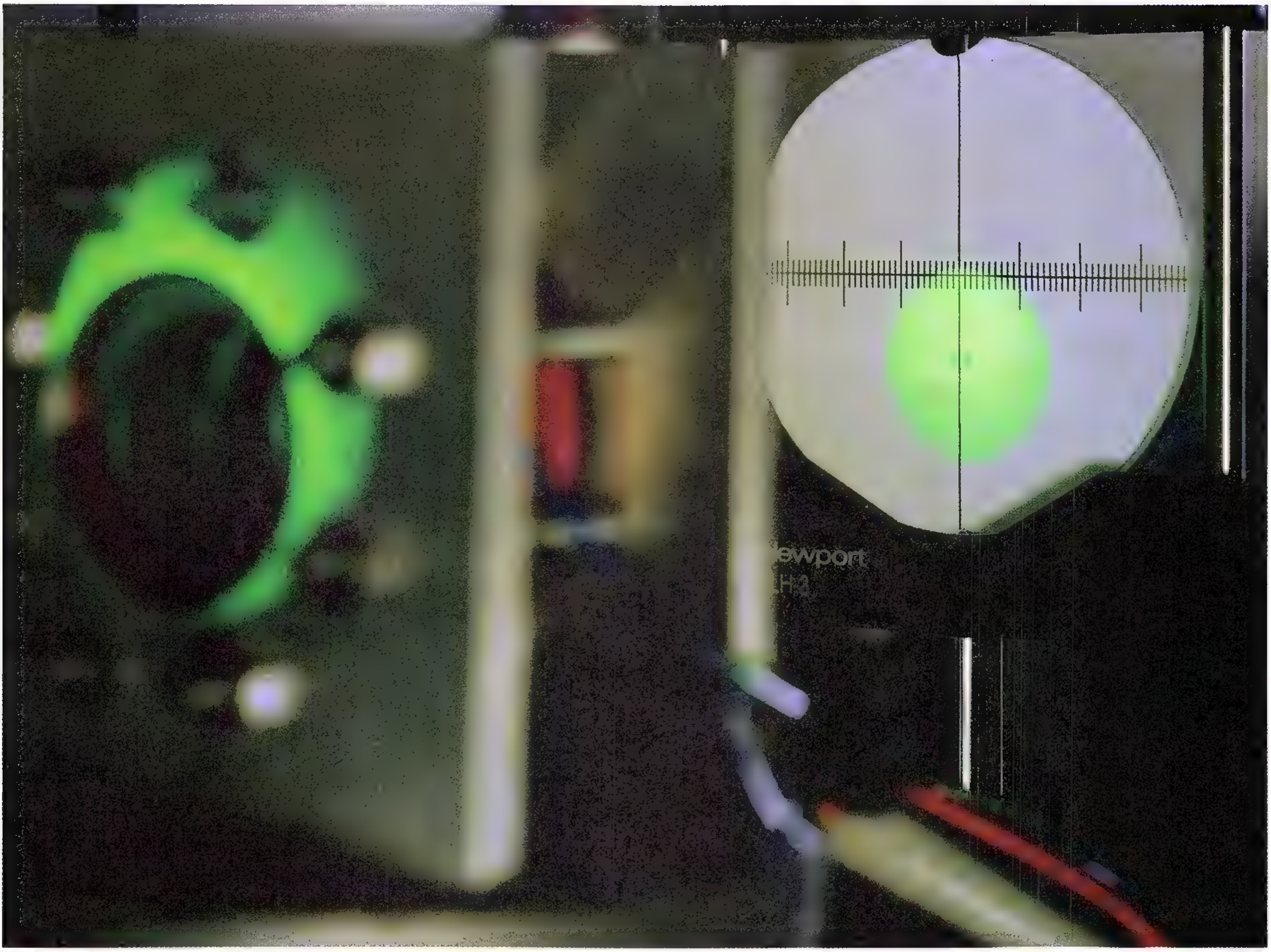
A lens made of glycerine changes power without moving (right). Could this spell the end of hefty zoom lenses?

It has proved difficult to make liquid crystal lenses big enough for imaging devices, but by suspending nano-sized droplets of liquid crystal in a polymer, Wu has been able to create larger variable lenses. He varies the distribution of the liquid crystal droplets in the polymer so that the refractive index changes with distance from the centre of the lens. Applying an electric field changes the refractive index of the liquid crystals, with the largest changes in areas where the crystals fill more space.

Another approach commissioned by Buckley avoids the problem of chromatic aberration by concentrating on a narrow range of wavelengths. Instead of liquid crystals, SBA Materials of Goleta, California, is using photochromic materials, like those used to turn spectacles dark when the light is bright. These materials consist of molecules that can exist in two states – a light-absorbing state that makes the lenses look dark, and a light-transmitting state that makes them clear. The molecules are switched between these states by light itself. Switching the molecules to a light-absorbing state also increases their refractive index at wavelengths close to the one that is absorbed. The materials being investigated by SBA are photochromic to visible and infrared light, but when they switch between states, they change the refractive index for the nearby blue or red visible light. This means that they could form the basis of UV or infrared-activated variable-focus lenses for visible light. Like Wu's team, SBA is also working on materials that change state in an electric field rather than when bombarded with light.

Demonstration of variable refractive power in single lenses is only a first step. Buckley is already thinking up ways in which the technique could be exploited for more complex systems and has put together some designs showing what optical systems of the future might do. One application he has in mind is as a replacement for complex, heavy and delicate zoom lenses. While a single variable refractive index lens could not do the job of zooming by itself, because the image could not be both magnified and remain in focus, Buckley has shown that two of them separated by a fixed distance could. That could make zoom lenses much simpler and more compact than they are now.

Buckley also has some more exotic ideas, one of which he presented at a conference of



MICHAEL WARREN FOR NEW SCIENTIST

"A car equipped with an infrared night-vision system and a variable lens could zoom in and out quickly, spotting different objects on the road while moving at speed"

the SPIE, the International Society for Optical Engineering, in Rochester, New York, last year. In the human eye, the central region of the retina has the highest density of light-sensing cells and so provides us with our detailed, high-resolution vision. While we can vaguely perceive objects in our peripheral vision, we have to move our eyes onto them if we want to study them. Buckley wants to mimic this ability of the human eye but without the lenses having to move. The idea is to control the refractive index across the lens so that, while one part of it focuses closely on one spot, the rest of the lens watches the surrounding area in less detail. If anything interesting happens elsewhere, the focus could shift.

A zoom lens made from variable refractive index lenses would be able to magnify part of its field of view without having to move, allowing a camera to zoom in for a close-up while keeping its peripheral vision alert for other action. In optical systems linked to image processing computers, the technique could dramatically reduce the processing power needed to analyse images by allowing a processor to gather fine detail on the most interesting parts of a scene while ignoring the rest. And because the lens does not have to move, optical systems could change their focus, gather data and move to decisions far more quickly. A car fitted with an infrared night vision system could zoom in and out quickly, spotting different objects on the road while moving at speed.

Just how fast all this could happen is anyone's guess. It'll be some years before these concepts can be turned into the high-quality lenses needed by commercial imaging systems. But once that happens, the design of optical systems will undergo a revolution and lenses will never be quite the same again. ●

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Letters

The taste test

From Frances Bell
Writers of detective fiction should update their poisoning scenarios following the introduction of "bitter blocker" powder (10 January, p 36). Instead of the murderer having to slip the poison into a strong cup of coffee and deflect comments about the strange taste, in new novels the murderer will be able to use any food or drink as long as a pinch of the AMP powder is mixed in with the poison.

Many harmful molecules – cyanide in apricot kernels, the sedative sesquiterpene lactone in wild lettuce and medicinal drugs – taste bitter not by chance but because evolution has developed this response to them. It prevents us from eating them and protects the plants.

I am horrified that our basic sense of taste is going to be interfered with in the name of greater profits for the food industry. We judge if food is fit to eat by several clues, but the final and vital one is: "does it taste OK?" Coffee tastes bitter so we don't drink it by the gallon. Medicines don't taste like food so we treat them warily. If the clues are no longer there, how can we avoid possibly fatal confusion?
Penrith, Cumbria, UK

Don't copy us

From Ralph deVoil
What should we do to plan for an environmental or otherwise self-inflicted disaster that collapses our civilisation, as Peter Inkpen discusses (20 December 2003, p 34)? What if our record of knowledge becomes lost for all time? Would this really be such a bad thing?

If said records were intended to assist a future civilisation to establish itself, then the best lesson that could be gained from such records would be some fairly strong clues about how *not* to conduct a civilisation. Perhaps along with the suggested Rosetta Stone, this preface should be applied to the recorded knowledge: "This is our knowledge at this time. If you're reading this after the collapse of our civilisation then it means that at least some of the methods we've used and documented here are evidently flawed. We hope that you don't make the same pathetic greed-driven mistakes that some of us did. Good luck."
Toowoomba, Queensland, Australia

From Mark Langford
Following a global disaster, how could we rebuild, especially when so much information is in digital form? Many readers are quite capable of building a workable generator, but what if you were presented with an abandoned copper mine and told to make the wire for the coils?

THE NUCLEAR BOMB PLAQUE STILL SEEMS HORRIBLY POPULAR

What I envision as the solution to this is the ultimate in hard copy. A basic grounding in the essential sciences – from agriculture upwards – should be engraved onto large, durable plaques. These should be made to withstand millennia of touching by visitors, and repeated in several languages at geologically stable locations around the globe, at least one per continent.

They must not be hidden. Instead, visitors must be encouraged. The plaques could be arranged in a labyrinthine walk with areas large enough for crowds to rest or picnic before particularly important information. Groups of schoolchildren could go on trips to view particular plaques. Visitors could take rubbings of desired sections so that they can peruse them again later.

The problem is, this is such a huge project I can only see it being organised online, with the data spending years on ageing hard drives before anybody raises enough money to make the plaques. By that time, of course, the earliest files will be completely unreadable by the latest version of Microsoft Office XXX...
Beccles, Suffolk, UK

Inherited fears

From Gal Levin, University of Texas Southwestern Medical Center
The interview with Brian Fallon about his work on hypochondria left me puzzled (6 December 2003, p 48).

He suggested that having an overprotective mother can make one hypochondriac. The emerging evidence that our genes determine around half of our personality suggests a different explanation: an innately health-conscious parent is more likely to have health-conscious sons and daughters than one who is not. That would make the problem "biological", according to Fallon's classification.

He says that selective serotonin reuptake inhibitors (SSRIs) result in a significant improvement in 70 to 75 per cent of his patients. Curiously, this is substantially higher than the effectiveness rate quoted for depression. Later in the interview he describes how strong the placebo effect is for this group of people. Perhaps the benefit can be largely attributed to this effect. The distinction is important because SSRIs are associated with serious side effects.

MEDICAL SYMPTOMS
DON'T LOOK – YOU MIGHT BECOME A HYPOCHONDRIAC

Fallon is unhappy with the information his patients find on the internet. And yet, entering a chat room, one knows what to expect: people's personal experiences subjectively interpreted. What I find more disturbing is that too often what one is getting from a physician is not much more.
Dallas, Texas, US

Nanocorrection

From Pat Roy Mooney, ETC Group
Jenny Hogan's piece on nanotechnology was baffling (20 December 2003, p 21).

She says the Canadian environmental group ETC is calling for a complete ban on nanotech. We have explicitly not called for a ban. Our policy calls for a temporary moratorium on lab research and new products until a national government, in conjunction with its scientific community, can establish a reviewable "best practices" protocol. We have never called for a blanket moratorium on all nanotechnology products or processes.

We wrote to a dozen leading commercial nanoparticle suppliers, asking for their own safety studies and information about others they may be familiar with. Only one supplier replied, and it provided no documentation. Further, we have participated in numerous formal and informal meetings and discussions with the nanotech industry and regulators on both sides of the Atlantic. None of the industry representatives we have met has dismissed our concerns about nanoparticle safety.

Hogan is quite right to say that ETC is primarily concerned about the ownership and control issues surrounding nanotech and its implications for the poor and for democracy. Yes, we have noted the worrisome parallels with the

See our website for letters on:
- ● Spam sham plan
- ● Safety bullet
- ● Speed of electrons

debate about genetically modified food – primarily because the nanotech community is constantly vowing not to repeat the same clumsy mistakes made with the introduction of biotechnology. But, contrary to their vow, they have been marching resolutely to biotech's drum.
Winnipeg, Manitoba, Canada

Doom in the sky?

From David Kent
Perhaps we should be even more concerned about NASA's attitude to safety than we are already. John Rummel, NASA's man in charge of our planet's safety, thinks that there is no danger in the Stardust Mission bringing material from the Wild 2 comet back to Earth because 40,000 tonnes of cometary stuff enters our atmosphere every year (10 January, p 11).

I have always assumed that this material wasn't carefully packaged in a capsule designed to protect it on its journey through the atmosphere.
Leeds, UK

Unsalted tarmac, please

From Alex Green
The amount of salt on Yorkshire's motorways over the winter, combined with bright winter sunshine, made car windscreens opaque within minutes. So yes, from drivers' point of view as well as the environment's it is time to use a safer alternative to de-ice roads – such as that in the patent described in "A greener antifreeze" (20 December 2003, p 29).
Basingstoke, Hampshire, UK

I TOLD YOU – TOO MUCH SALT IS UNHEALTHY

Good vibrations

From Godfrey Dack
In "Mingle bells" you say the fundamental on a stretched string has a wavelength equal to the string's length (13 December 2003, p 41). In fact, it has a wavelength of twice the string's length (easy school science question).

Can you tell I am a bored retired further education college lecturer?
Hull, Yorkshire, UK

From Barry Manor
Philip Ball's article states that for a vibrating string, "... the fundamental is a single standing wave with a wavelength as long as the string". However, common experience suggests this isn't the whole story. All the strings on my guitar have different pitches, even though they are all the same length. The frequency also depends on the tension in the string and its mass per unit length.
Epping, New South Wales, Australia

Spam sham plan

From John Rockwell
Brian Fattorini has my sympathy over his "Spam tsunami" (13 December 2003, p 35). Surely a complete solution would involve destroying the spammers' business model?

All you'd need to do is create a law allowing the formation of a company that could legally submit false orders. The company could be run by a consortium of major companies, which would volunteer the personnel to staff it.

These staffers' job would be to identify true spam and then programmatically create millions of false orders in response to it. Banks could even provide dummy charge account numbers for verification. Since the spammers rely on a response rate of about 0.5 per cent to make sending out reams of junk profitable, increasing the rate to 20 per cent would hide the few real orders among myriad fake ones and make spamming uneconomic.
Palm Harbor, Florida, US

Sunspotting

From Barry Horne
Lev Pustilnik and Gregory Yom Din are reported to be looking for more examples of synchronisation between the sunspot cycle and markets (20 December 2003, p 8). They could try looking at *Sunspots and their Effects* by Harlan True Stetson. Back in 1937 he pointed out the synchronisation of the Dow Jones Index, tree growth, wine vintages, car production, building contracts and more with the sunspot cycle.
Dunstable, Bedfordshire, UK

Not now – now now

From Andrew McDonald
The Scots and the Welsh don't have a monopoly on time travel (22 November 2003, p 35 and 13 December 2003, p 35). Many a visitor to South Africa must have thought they'd travelled through some sort of time tunnel. If a South African tells you they will do something "now", they mean "when I can get to it" (often the next day). If they say "just now", they mean sooner than "now" but not necessarily immediately. Fortunately, they have a term which is used when there is some sort of urgency, the rather amusing "now now".
Cape Town, South Africa

Head boys

From Xue Rui
Feedback mentions the James Watson bobble head and asks which other scientists are so honoured (13 December 2003). Archie McPhee has been making Einstein action figures for a while now. You can find them at www.mcphee.com/amusements/action.html. While you are there, check out Jesus, Moses, Freud, Ben Franklin and Shakespeare too.
New York, US

From Richard Watanabe
Considering that there was a cartoon of ol' Albert at the top of your column, I was surprised to see that Watson was the first doll you had heard of. Of course, over on this side of the Pond the first (and often the last) scientist anyone has ever heard of is Big Al.

I am an exhibition designer specialising in science museums, and a basic tenet of the profession is that it's better to show the real thing than a photo or a description. So herewith please find your Albert Einstein bobble-head doll. Enjoy.
South Hadley, Massachusetts, US

Feedback writes:
● Many thanks. Einstein is nodding sagely on the window sill even as this is being written.

For the record

● MiG-29 aircraft have fixed wings, contrary to what we said on 13 December 2003, p 28. We could have referred to the MiG-23 or MiG-27 as examples of variable-geometry planes.

● Letter writer Samuel Thomas would like to clarify that he is still an undergraduate student of chemistry at King's College London (20 December 2003, p 34). The course is being phased out over the next three years.

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Dancing the quantum dream

They weave in and out of each other's paths, solving breathtaking problems at each new turn. Are these knotted particles our brightest hope for a quantum computer, asks **Paul Parsons**

PERHAPS we should have recognised the power of weaving long ago. After all, it was a weaver who wrote the world's first ever computer program. In 1801, Frenchman Joseph Jacquard created an automated loom that could weave complex designs into cloth according to the pattern of holes in a series of punched cards that he fed into the machine – and it was nothing short of revolutionary. By 1812, there were 11,000 of Jacquard's looms in service, and they changed the face of the textile industry.

Now there's another weaving revolution waiting in the wings, and this time it's computing, not the rag trade, that will reap the benefits. The twists and turns of weaving are promising a new breed of high-performance computer that will be able to solve problems so complex they would take today's fastest processors longer than the age of the universe. This is no ordinary weaving, mind you. We're talking about weaving in the quantum world, the realm of subatomic particles.

The idea of using the quantum world to perform calculations began with the late physicist Richard Feynman. He wanted to simulate the complexities of the universe in a computer and, realising that no conventional computer was up to the job, dreamed up the "quantum computer". He pointed out that some computations boil down to solving equations that also describe situations in quantum physics – for example, what happens when two electrons bounce off one another. Many of these computations are what mathematicians call "NP-hard": the number of computational steps needed to find a solution grows exponentially with the number of variables involved, quickly rendering them unsolvable on conventional computers.

Feynman suggested a quicker route: do the quantum experiment – bounce two electrons off each other, say – and work out a way to read the result. In other words, find a physical situation where the maths governing the physics mirrors the maths you are trying to solve. An added attraction of this approach is that once you can solve one NP-hard problem, many other NP-hard problems succumb to exactly the same kind of solution.

It was a brilliant idea, and a few years later, David Deutsch of the University of Oxford turned Feynman's sketch into a detailed blueprint, showing how to encode a computation in a quantum system and thus perform NP-hard computations. Almost immediately, researchers began coming up with applications for the machine. Among the most notorious is in code-breaking.

The security of many of the world's encryption technologies depends on the intractability of one particular NP-hard problem: finding the factors of large numbers. A classical computer would take hundreds of millions of years to factorise a number just 300 digits long, and so encryption techniques such as the popular "RSA" method have used the hidden factors of these numbers as a basis for establishing secure codes. But in 1994 Peter Shor of AT&T's Bell Labs showed how an array of quantum logic gates – a quantum computer's equivalent of the standard logic gates of computation – could find the factors and crack such codes in seconds.

However, no one has succeeded in developing a useful quantum computer, although there are a number of prototypes in development. Most aim to process quantum bits, or "qubits" of information encoded in the states of particles such as trapped ions or atoms ▸

DAVE McKEAN

held inside silicon chips. But the machines all face one big problem. They have to be carefully shielded to protect them from "decoherence" – any disturbance can allow information to leak out, ruining the computation.

This is where quantum weaving comes in, potentially eliminating the problem altogether. This solution to the quantum computer's problems is nearly as old as the idea of a quantum computer itself. In 1987 Vaughan Jones, a professor of mathematics at the University of California, Berkeley, published an extraordinary discovery. He showed that certain abstract structures called von Neumann algebras – which enable mathematicians to handle quantum mechanical variables such as energy, position and momentum – are related to the mathematical theory of knots, and provide a way to tell very complicated knots apart. Jones won the Fields Medal for this insight, the highest accolade in maths.

Jones's work also proved that knots can store information – any given knot can be specified in terms of an array of 0s and 1s, determined by the knot's twists and turns. Tie that knot and you have effectively stored those numbers. And since the logic gates used by computers can all be expressed as matrices of 1s and 0s, tying a knot can also encode the logic operations necessary for computation.

The string theorist Edward Witten, based at the Institute for Advanced Study in Princeton, was the first to connect Jones's work with its consequences in the physical world.

> **"By moving particles about you can weave their world lines around each other and tie knots that encode information – numbers and computations"**

Witten showed that you can move quantum particles around one another to form a braid – one that exists in space and time, a sort of plait whose strands are the histories of the individual particles. Doing this should affect the quantum states of the particles in a way that is directly related to the properties of the braid you create. In other words, performing measurements on a braided system of quantum particles can be equivalent to performing the computation that a particular knot encodes.

The beauty of this is that the maths behind these braids, like the computations Feynman wanted to perform, is NP-hard: as the knots get more complicated, the equivalent computations that they encode correspond to problems of rapidly increasing difficulty.

With Witten's insight, published in 1989, it seemed that Feynman's idea had become reality: the properties of quantum particles could indeed give answers to previously intractable problems. But no one knew of a real quantum system that would do the job Witten had outlined. It was eight years before Caltech computer scientist Alexei Kitaev found one.

Kitaev showed how Witten's topological interpretation of quantum theory can indeed form the basis for a computer (*Annals of Physics*, vol 303, p 2). Using quantum particles with just the right properties, braiding can efficiently carry out any quantum computation in super-fast time. And while traditional qubits are prone to decoherence, Kitaev's calculator is robust: just as a passing gust of wind may ruffle your shoelaces but won't untie them, data stored on a quantum braid can survive all kinds of disturbance.

It was at this point that another Fields medallist, Michael Freedman of Microsoft Research in Redmond, Washington, came onto the scene. Freedman, an expert in topology, had been fascinated by Witten's work, but couldn't find a way to take it forward. When he saw Kitaev's paper, he got in touch, and the pair have been working together ever since.

Freedman and Kitaev (who is now also at Microsoft Research), together with Michael Larson and Zhenghan Wang, both at Indiana University in Bloomington, have now shown how to build a "topological quantum computer" using technology that is available today (www.arxiv.org/quant-ph/0101025). It seems to be the one machine that could get useful quantum computers off the drawing board.

So how does it work? The trick is to think of space and time as a unified four-dimensional entity. Even particles that are static in space are hurtling through time, tracing out a long thin "world line" in this 4D space-time. So by moving particles about you can weave their world-lines around each other and tie knots that encode information – numbers and computations. "You reach in and start braiding the particles around each other, like someone braiding hair," Freedman says.

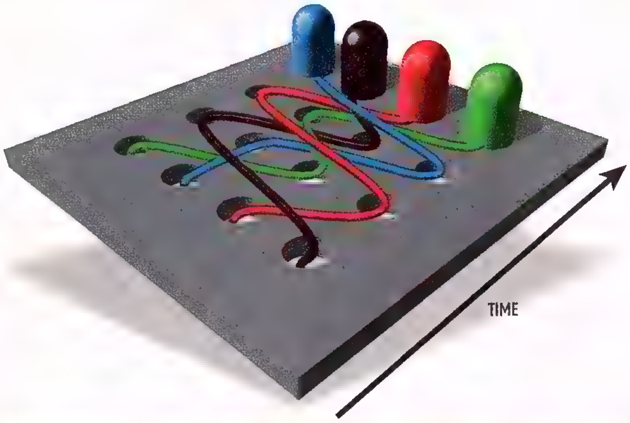
So far, so good. But measuring how a handful of identical subatomic particles have been braided round each other is impossible, at least for everyday subatomic particles such as electrons and protons. That's because braiding doesn't affect the observable properties of most particles, which means you can't tell anything about the braid – and thus the computation – from examining them.

The way round this is an altogether different type of particle, called a "non-Abelian anyon". Actually, it isn't strictly a particle: anyons are blobs of subatomic particles that behave as if they were a single particle, and have one-third the electrical charge of the electron.

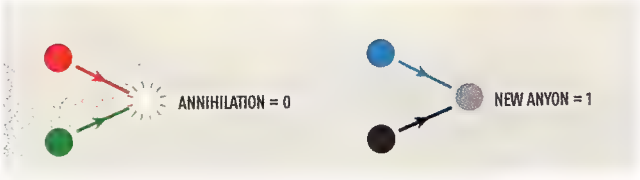
WEAVING A QUANTUM COMPUTER

The topological quantum computer works by braiding particles called non-Abelian anyons

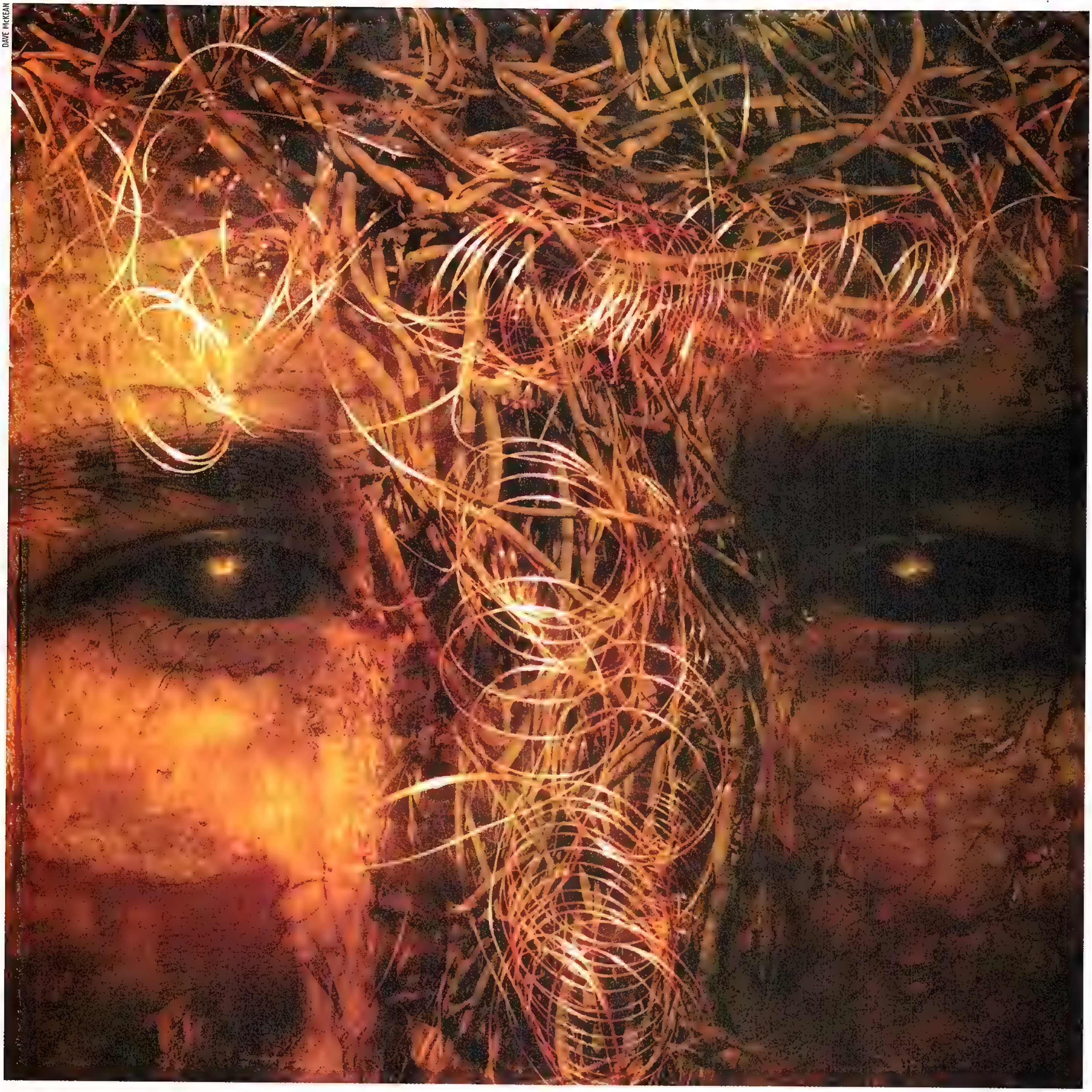
The anyons trace out "world lines" as they travel through space-time. Swapping their positions weaves the world lines into a braid, which affects their "topological charge" in a specific way. Knot theory says the weave of this braid can encode a computation, and comparing the anyons' final topological charges gives you the outcome of the computation



Topological charge is read off by bringing the anyons together in pairs. Those with equal and opposite topological charge annihilate, creating a "0" output. Pairs with unbalanced charges fuse to form a new anyon, and create a "1" output



DAVE McKEAN



Non-Abelian anyons occur in pairs, n much the same way that pairs of particles and antiparticles bubble up from the vacuum of empty space. Each one in a newly created pair carries equal and opposite amounts of a quantity called topological charge. This is not charge in electrical terms but, like the strangeness or charm that quarks can carry, simply a label that describes a basic property of the particles and tells different types apart. The topological charge serves to distinguish one anyon from another as they are braided.

Unlike the fragile qubits in other quantum-computing systems, the information encoded in anyons is robust. That's because topological charge, like electrical charge, can only be cancelled out by an equal and opposite charge. "The state of the quantum computer is stored in the conserved charges that the anyons carry," says John Preskill of Caltech. "Even if you hit an anyon with a hammer, you can't change that charge, so the state stored in the computer is quite robust."

To perform a computation, you arrange the anyons in a row and then literally grab pairs of particles and swap their positions to create a braid in their space-time world lines (see Diagram, p 32). By carefully choosing your particular braiding pattern you can encode the quantum logic operations of the computation you wish to perform.

That correspondence between logic operations and braid designs is complicated – even Freedman admits he can't visualise it as anything other than abstract mathematics. "It's sort of the end of a long calculation," he says. However, the actual process of braiding is not so complex. It could well be possible to do it with a device similar to a scanning tunnelling microscope.

Once braiding is complete, it simply remains to press the "equals" key. You do

▶

"They might be bad news for security and encryption, but these machines will also perform lightning-fast searches through databases and run simulations of the birth and evolution of the universe in unprecedented detail"

WHERE DO ALL THE ANYONS COME FROM?

The signature of anyons was first seen in 1982 at Bell Labs in New Jersey, when researchers were studying the "quantum Hall effect".

The classical Hall effect is named after Edwin Hall, a graduate student at Johns Hopkins University in Maryland in the late 19th century. Hall found that when a thin sheet of metal with an electrical current flowing through it is placed in a magnetic field, it creates a small voltage across the sheet, at right angles to both the current and the field.

In 1980, German physicist Klaus von Klitzing re-examined the Hall effect, but instead of metal he used a thin sheet of semiconductor at 1 Kelvin. He found that the Hall resistance – the observed voltage divided by the applied current – didn't vary smoothly as the magnetic field strength changed, as it had done for Hall, but instead changed in discontinuous jumps. The very low temperatures of the experiment had allowed quantum behaviour to come into play. Klitzing found that the size of the jumps was given by a combination of physical constants from quantum theory, including the charge of the electron.

Two years later, a team from Bell Labs repeated the experiment, but this time using the purest semiconductor samples ever made, cooled to less than 300 mK and subjected to a magnetic field nearly a million times as strong as the Earth's. Again, the Hall resistance varied in jumps, but now there were new steps, above and between those that Klitzing had seen. The distance between the new steps could only be accounted for if the electrical charge of the current-carrying particles had somehow dropped to just one-third the charge of the electron. It was as if the electrons had somehow split into three.

Shortly after this, physicist Robert Laughlin, now at Stanford University in California, constructed a theory that explained the result through the action of a new quantum entity: an anyon.

this by bringing together the pairs of adjacent anyons in the row. Pairs that have equal and opposite topological charges annihilate, while pairs with unbalanced charges fuse to form a new anyon. The final output of the computation is then a string of 0s and 1s – a 0 for each pair that disappears and a 1 for each pair that does not. And these could be read out using a probe that looks for the presence of anyons.

That's not quite the end of the story, however. The quantum nature of the topological charge means that it doesn't actually have a definite value. Although there is a value that is the most probable outcome of a measurement, there is also a chance of getting a range of other values from the measurement. So on one run of a computation, bringing together a particular pair of anyons might lead to their annihilation, giving a 0. Yet on the next run, there is a chance they might fuse to create a single anyon, giving a 1. "The answer to the computation is phrased in terms of this probability," Freedman says. "By doing the computation many times we can approximate what that probability is, and that's the information we want to know."

The number of times the computation has to be repeated is in linear proportion to the accuracy you want, or at worst in proportion to its square. So if you needed to know the result to an accuracy of, say, +/- 10 per cent, then you might have to do the experiment 100 times.

It sounds time consuming, but it's not. "These anyons are very small and very close to each other," says Freedman. "Braiding them around each other involves very small movements and these can be done in nanoseconds." By comparison, the time taken to perform a calculation on today's classical processors typically increases exponentially with the required accuracy.

So why aren't Microsoft rushing a topological quantum computer onto the market – what's the hitch? Well, it's a big one: no one is certain that non-Abelian anyons actually exist. Ordinary anyons certainly do: they are created in a semiconductor phenomenon called the fractional quantum Hall effect (see "Where do anyons come from?"). But no one has ever seen the non-Abelian variety. The good news is that everything in quantum theory says they should exist, and that they can be made. "Mathematically we know [they] are out there – we see them in our models," Freedman says. "If quantum theory is correct, then it's certain we'll make them."

Chetan Nayak, a quantum computation researcher at the University of California, Los Angeles, agrees and even suggests that the particles may have been produced already. "It is quite likely that a particular type of non-Abelian anyon exists in one of the observed fractional quantum Hall states," he says.

Others are trying new methods: Lev Ioffe, a condensed-matter physicist at Rutgers university in New Jersey, is experimenting with arrays of superconducting junctions. He hopes to make anyons by the end of this year, and believes the same approach will yield the non-Abelian variety. "I think non-Abelian anyons will eventually be possible," he says.

So despite the practical hurdles ahead, many researchers are cautiously optimistic about the prospect of topological quantum computers. "The obstacles are daunting but, eventually, I think they will work," says Preskill.

If these machines can be built, the range of potential applications is unlimited. They might be bad news for security and encryption, but they will also perform lightning-fast searches through large databases, and run simulations of the birth and evolution of the Universe in unprecedented detail. Yet Freedman believes those are peanuts compared with the possibility of a "virtual lab". "I think the most important application of quantum computers will be to predict the behaviour of materials without making them," he says.

At present, engineers largely resort to experiment to determine a material's properties, such as its strength or flexibility. Although certain calculations can help, these properties are ultimately determined by quantum physics, so quantum computers are the natural machines to model them. This could allow engineers to tailor-make the materials they need – and that includes making new semiconductors, the very materials that could give rise to non-Abelian anyons. "In a sense one of the applications of quantum computers will be to build more quantum computers," says Freedman.

And then what? No one knows, but one thing is clear. Ever since the Jacquard loom people have never failed to find innovative and unexpected uses for the increasing computing power at their disposal. Why should the power of quantum weaving prove any different? ●

Paul Parsons is the editor of *Focus* magazine

www.newscientist.com/hottopics

GRAHAM RAWLE

Leave it, Steve. He's not worth it...

Out with the lads

Our habit of hanging out with friends of our own sex has many parallels in nature. Why are single-sex groups so common, asks **Catherine Lewis**

GIRLS in the bedroom playing with their dolls. Boys in the back alley chasing one another. Mothers nattering on a park bench. Lads at the pub. Women round the photocopier gossiping about their colleagues' indiscretions. Men in the boardroom discussing the performance of their competitors.

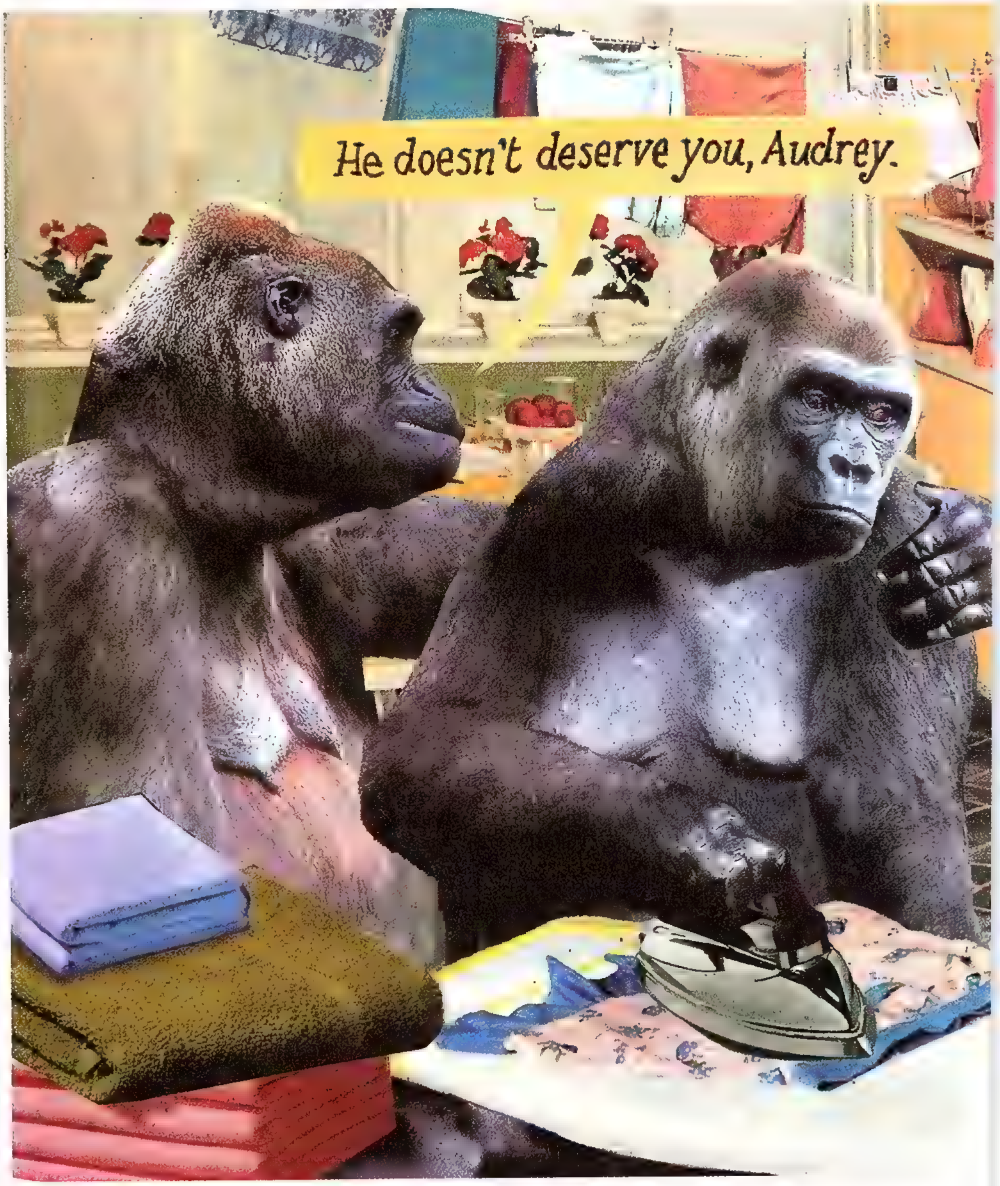
These are blatant sexual stereotypes but, like most stereotypes, they contain at least a grain of truth. We humans do often choose to hang out with friends of the same sex. What's more, this behaviour, far from being aberrant, is common throughout the animal world. The experts call it "sexual segregation" and it is practised by all sorts of species, from chimps and polar bears to albatrosses and dogfish. Until recently, it had been studied primarily in ungulates, but now we are starting to get the bigger picture. And, as it becomes more apparent why many animals separate into different sex groups we are starting to see how our human behaviour fits into the jigsaw.

That male and female animals should ▶

band together in separate groups within a herd is puzzling at first glance. But there are several possible explanations. The first focuses on habitat and the notion that males and females choose to congregate in different areas that reflect the requirements of their differing lifestyles. Lactating mothers, for example, might need to eat higher-quality forage and choose their habitat accordingly. The second idea is that segregation stems from the two sexes being subject to different predation pressures. Nursing females might be more at risk than males, for instance. A third idea links segregation with energy requirements and activity levels. This "activity budget hypothesis" assumes that in some species males and females spend unequal amounts of time active or inactive. The more the sexes differ in their activity levels, the more difficult it is for them to stay together, which is why males and females segregate.

In an attempt to tease apart these ideas, Kathreen Ruckstuhl and Peter Neuhaus from the University of Cambridge looked at 30 species of ungulates that form single-sex groups within the herd. They found that varying activity levels between males and females could largely explain segregation, with predation risk and foraging selection playing smaller parts. A follow-up study indicated that, in theory at least, activity budget differences alone can create sexual segregation.

Teaming up with Hanna Kokko from the University of Jyväskylä in Finland, Ruckstuhl created a computer simulation in which males and females were distinguished only by their activity levels and their patterns of switching from being active to inactive, with males being more ready to get up and more reluctant to lie down than females. All the individuals were social: programmed to congregate with others they encountered. "As sexual differences in activity budgets increase, the degree of sexual segregation significantly increased," says Ruckstuhl. "Sexual segregation reached a peak of around 74 per cent when sexual differences in activity budgets were greatest" (*Animal Behaviour*, vol 64, p 909).


He doesn't deserve you, Audrey.

GRAHAM RAWLE

Segregation by size

Ruckstuhl concludes that in ungulates, at least, different levels of activity between the sexes largely explains segregation. But not all ungulates divide neatly along sexual lines. She wondered whether she could predict which species would do so and which would not. The obvious starting pointed was body size dimorphism, because sexual segregation tends to be most common in species where one sex is larger than the other. And there is a huge range of variation between ungulate species, from Alpine ibex, where males are around twice the size of females, to animals such as oryx and zebras, where both sexes are the same size. When Ruckstuhl and Neuhaus looked at data for 30 species of ungulates they found that the watershed was 20 per cent – species with at least this difference in size between the sexes tended to form single-sex groups.

Ruckstuhl's findings have gone a long way towards unravelling the mystery of sexual segregation in ungulates. But what of other animals? At a meeting organised by Ruckstuhl in September 2002, biologists studying this odd behaviour in a variety of species had a rare opportunity to compare notes. One thing that became apparent was that sexual segregation is not to be undertaken lightly. It can have fatal consequences for albatrosses and giant petrels, for example, both of which segregate because males and females choose different hunting grounds. While males stay close to shore, females go on long foraging trips out to the open ocean. Studies by Jose Xavier from the University of Cambridge, Jacob Gonzalez-Solis from the University of Barcelona, Spain, and their colleagues from the British Antarctic Survey found that the female hunting areas overlap with long-line fishing activity and that birds getting caught up in the lines is the main reason for the highly skewed sex bias in the mortality of these species. The researchers believe it is also the most likely explanation for their dramatic decline in recent years.

As well as driving home the message that segregation can be a conservation issue, the meeting also served to highlight just how common the practice is, and the wide variety of underlying causes. Sexual segregation occurs in several solitary species. It sounds like a contradiction in terms, but in practice, this simply means that males and females hang out in different environments. Dogfish do it, and David Sims of the Marine Biological Association in Plymouth, UK, is trying to find out why. Grizzly bears segregate so that females can avoid contact with infanticidal males. And even among ungulates, the activity budget hypothesis doesn't explain all instances of segregation. Johan du Toit from the University of Pretoria in South Africa has found that male

She's right, love.
They're all the same.

"Sexual segregation is uncommon among non-human primates. Temporary all-female or all-male associations tend to be linked with mating behaviour"

and female giraffes browse on the same trees but at different heights to avoid competition. And male and female kudus, an African antelope, segregate primarily to avoid being eaten. Leopards are more of a problem for females, and lions for males, so each sex tends to occupy areas that have lower densities of their respective predator.

Bats do it for their babies

Bats also segregate by sex for a whole range of reasons. Robert Barclay from the University of Calgary, Canada, has found that male brown bats (*Myotis lucifugus*) and long-eared bats (*Myotis evotis*), which live in the Canadian Rockies, tend to forage further up the mountainside than females. Males in these species spend the cold nights in a sort of temporary hibernation known as torpor, whereas females cannot go into torpor when they are pregnant because it would endanger their developing fetuses.

John Altringham and Paula Senior from the University of Leeds, UK, found a similar pattern when studying Daubenton's bats (*Myotis daubentonii*). In this species some males forage for food higher upstream than the females. They suggested that the energy demands of pregnancy and lactation might keep females from living at higher elevations or in areas where density of prey is unpredictable. Males can save energy by entering torpor if foraging conditions are bad, but pregnant females do not have that option. Ruckstuhl believes that bats would be a good group in which to search for general patterns underlying sexual segregation, as there are well over 1000 species, many of which engage in the behaviour.

With so many unanswered questions, the field is certainly ripe for further research. African ground squirrels, for example, segregate strictly by sex but no one is sure why. Mysteriously, mice seem to start their sexual segregation in the uterus, with males aligning on one side and females on the other. Nobody knows whether invertebrates segregate by sex. Information is very limited, although likely suspects include the horned beetle, where there is a clear size difference between males and females. But size dimorphism is not always an indicator. Studies of whales by Robert Michaud from Dalhousie University in Halifax, Canada, reveal that there is usually sex segregation in species where males are much larger than females, with one striking exception – male and female orcas or killer whales, which live in family units called pods. The reason remains unclear.

And what about primates? Sexual segregation is uncommon among our closest living relatives even where males are much larger than females, according to David Watts from Yale University. In some species there are temporary same-sex associations, which tend to be linked with mating behaviour. Among chimps, for example, all-male bands roam their territories to fight off intruders or to check on oestrous females. Spider monkeys also segregate by sex. Could such behaviour provide any clues about our sexual segregation?

We undoubtedly show an extraordinarily high level of sexual segregation for a primate. And, unusually, it starts early in life. Anthony Pellegrini from the University of Minnesota, Twin Cities, has spent many hours observing and analysing children at play. He has found that boys tend to engage in rough-and-tumble play with lots of running around, whereas girls are less energetic. In other words, boys and girls have different activity levels, and this tends to split them into same-sex groups – supporting the activity budget hypothesis.

But could this simply be a product of upbringing and cultural background? Melissa Hines from City University, London, has found biochemical reasons underlying a tendency for children to seek out playmates of the same sex. Her studies show that tomboyish behaviour is associated with female fetuses being exposed to higher than normal levels of androgens (male hormones) in the womb. But Hines cautions that the reasons for segregation are not simply biochemical. "Boys discourage other boys from playing with girls," she says. And single sex associations are both positively and negatively reinforced by children and adults, with boys being more strongly socialised to be boyish.

The reasons for sexual segregation among adults are equally tricky to pin down. They include common interests, a shared outlook on life, and differences in status. But perhaps the best place to look for their biological roots is in traditional societies where strict sexual segregation is the rule, with men hunting and women gathering food. Kristen Hawkes from the University of Utah, Salt Lake City, has spent many years studying modern forager ecology and is convinced that sexual selection underpins this segregation. She points out that men could provide more calories by helping gather roots and berries. But hunting is a way of showing off, and men who are good at it tend to have more sexual partners and enjoy higher status.

If Hawkes is correct, sexual segregation among human adults has its origins in mating behaviour. So it looks as if we are not so very different from other primates after all. And children seem to play in single-sex groups because of their different energy levels – segregating according to activity budgets, just as many animals do. But it is still a mystery why we humans are so much fonder of consorting with our own sex than other apes are. "What I find fascinating is that wherever you go, you always get men and women forming separate groups, even at conferences," says Ruckstuhl. None of us is immune, not even the people researching sexual segregation. ●

Catherine Lewis is a UK-based writer and editor

S. KRASEMANN / NHPA

Number of the beasts

More and more animals are revealing unsuspected mathematical talents. And they're teaching us a thing or two about how our own brains deal with numbers, says **Emily Sohn**

MATHEMATICS often ranks alongside language and opposable thumbs as one of those things that separate man from beast. But again and again, the beasts are proving us wrong. "Every time people say animals can't do X," says Irene Pepperberg, who has spent years studying the skills of an African grey parrot named Alex, "we find yes, they can. They can do X + 1."

From birds that count, to chimpanzees that add, to salamanders that know the difference between two and three, it looks as though an inborn sense of number is one of the most basic cognitive abilities around. And a range of studies show that animals and people deal with numbers in some remarkably similar ways.

As cross-species findings continue to pour in, researchers think they are getting closer to understanding how brains work with numbers. Universal quirks in mathematical abilities could shape better teaching strategies, and decoding the number response might reveal some basic brain mechanisms. Understanding numeracy might even yield clues about what goes wrong in disorders such as schizophrenia and autism.

That numeracy skills are found throughout the animal world makes a lot of sense. Figuring out which tree has more berries on it, or determining whether there are more friends than enemies in an area, are matters of life and death. "If you know there are six lions in the pride and you only see four," says behavioural neuroscientist Randy Gallistel of Rutgers University in New Jersey, "there is probably some survival value to wondering where the other two are."

Not surprisingly, some animals are more gifted than others (see Graphic opposite). "You go from the very simplest perceptual recognition of bigger versus smaller to the absolute be-all, end-all of being able to understand complicated mathematical equations," says Pepperberg, who works at the University of Arizona in Tucson and is also a visiting professor at the Massachusetts Institute of Technology.

Alex, a 27-year-old parrot in Pepperberg's lab, for example, can count and distinguish between more and less, among other skills. He can look at a collection of blue and red blocks and tell how many blue blocks there are. Pepperberg also believes that Alex is learning not only that the symbol "3" represents "threeness", but also that the symbol "4"

> "If you know there are six lions in the pride and you only see four, there is probably some survival value to wondering where the other two are"

represents something bigger. Chimpanzees can do similar tasks. Pigeons appear to be less numerate but can distinguish between different numbers of objects, however big the objects are or however much space they take up. Rats don't seem to grasp abstract concepts of number at all, but can learn to press a lever close to a specified number of times.

But whatever mathematical tricks animals can be taught, they learn about numbers in a different way to children, says Claudia Uller, a cognitive scientist at the University of Essex in Colchester, UK. For one thing, children learn much faster than primates. "In order to teach a chimpanzee to learn a symbolic number system, you have to make it learn 'oneness', then 'twoness', then 'threeness', and that takes it forever," Uller says. Children, on the other hand, usually reach some kind of "eureka" moment at around age 3, when it just clicks that there is always a bigger number than the one you've just counted. It is more interesting to look at what animals can do spontaneously, without any training at all, she says – that's what tells you about our innate sense of number.

One classic technique for testing innate number abilities was developed for studying human babies. More than a decade ago, Karen Wynn, a developmental psychologist now at Yale University, found that babies look measurably longer at things that are novel or surprising. For example, when 6-month-old babies see one doll go behind a screen, then another, they expect to see two dolls if the screen is lifted. The babies will look longer if they see three dolls, or one, rather than two. This may indicate a primitive ability to count. Similar experiments have shown that rhesus macaques can add and subtract small numbers of objects, as can cotton-top tamarins, an even more distant relative of ours.

More recent experiments have explored a still more basic number skill shared by primates and babies: the ability to understand "more" and "less". Last year Harvard psychologist Susan Carey and her colleagues showed that 10 and 12-month-old babies will crawl up to a container with two cookies rather than just one. Likewise, rhesus macaques will choose a box with three apples rather than two.

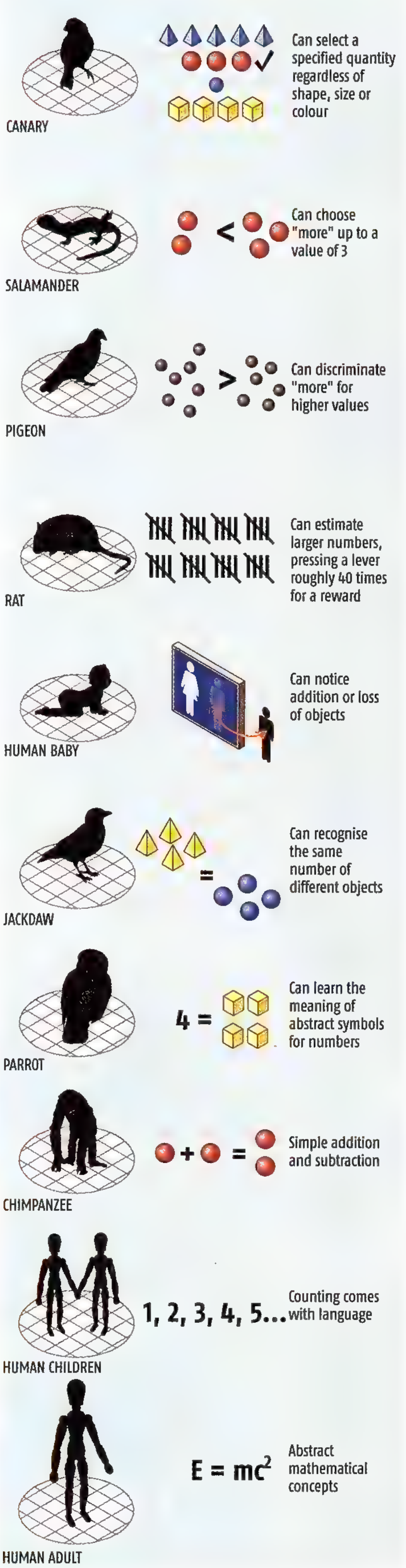
Hoping to look even further back in our evolutionary history, Uller did the same experiment with red-backed salamanders. Instead of cookies or fruit, salamanders chose between test tubes containing different numbers of fruit flies. Consistently, Uller found, the amphibians touched their snouts to the tube that held more flies. Her study was the first to show that an animal other than a primate might be able to pick the larger of two numbers of objects in the same way that babies do. "What this says," says Harvard biologist

Whether it's keeping tabs on your eggs (left) or learning to count, number skills appear everywhere

ANN CLOPET/CORBIS

MATHEMATICAL MINDS

From equality to equations, many animals have a talent for maths


CANARY
Can select a specified quantity regardless of shape, size or colour
SALAMANDER
<
Can choose "more" up to a value of 3
PIGEON
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Can discriminate "more" for higher values
RAT
Can estimate larger numbers, pressing a lever roughly 40 times for a reward
HUMAN BABY
Can notice addition or loss of objects
JACKDAW
=
Can recognise the same number of different objects
PARROT
4 =
Can learn the meaning of abstract symbols for numbers
CHIMPANZEE
+ =
Simple addition and subtraction
HUMAN CHILDREN
1, 2, 3, 4, 5...
Counting comes with language
HUMAN ADULT
E = mc²
Abstract mathematical concepts

Marc Hauser, "is that the building blocks for higher mathematical capacity are built onto primitives that evolved way before we were even on the planet."

Similarities between different species are striking, Uller says, not only in what they can do, but in what they can't. Across the board, performance seems to drop off around the number four. "It's so incredible," she says. "If you give babies a choice between two and three, they'll go for three. At three versus four, they're random. At four versus six, they're random." Likewise, rhesus monkeys can understand one versus two and two versus three, but not three versus four or four versus six. Salamanders show the same patterns. Even human adults can keep track of four moving dots on a computer screen, but not more.

To some researchers, including Uller and Hauser, the universal failure at four suggests that the brain has two separate systems for dealing with numbers. One, called the large approximate system, covers the big numbers and relies on a keen sense of estimation. That would explain why rats and pigeons can learn to press a lever as many as 45 times to get a reward, but the margin of error increases as the target number gets bigger. Humans behave in the same way. You can test yourself: guess how many geese are in a flock, for instance, then count. You'll probably come pretty close.

The small number system, on the other hand, is theoretically more specific and precise. Also called "object indexing", this theory holds that the brain opens one "file" at a time to keep track of individual objects, but can have only four or five files open at once.

"To me, it raises more problems than it solves," says Gallistel, one of the most vocal critics of the two-system theory. Put simply, the problem is that you can add small numbers together to get a big one, or subtract one big number from another to get a small one, and these operations would require both systems. It is not clear how the system that handles the question could interact with the one that handles the answer.

Brian Butterworth, a neuropsychologist at University College London, sees further problems with the two-system explanation.

Nice try, but you need language to play even the simplest number games

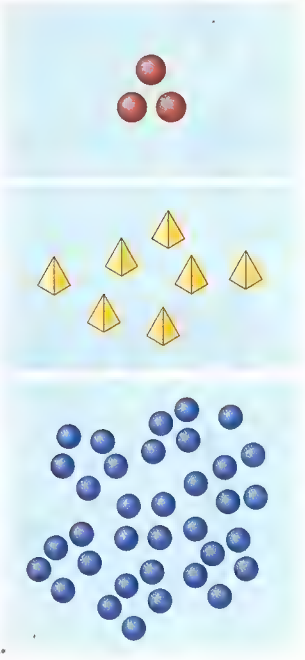
He agrees we can look at a group of objects and estimate that there are lots of items, but thinks this is not the same as translating an estimate into a large number. Large number skills develop with language skills, he says.

But he also agrees that we are born with an ability to deal with small numbers. His explanation focuses on our uncanny ability to "subitise". Up to four or five objects, most people can tell how many there are just by looking, without counting each one. But if there are more objects, we have to count. Based on work with brain-damaged people who can't subitise, Butterworth argues that there is a "number module" in the brain:

MARILYN SILVERSTONE/MAGNUM PHOTOS

NUMBER GAMES

We seem to deal with big and small numbers in different ways



For numbers below five, you just know how many there are without counting

Above five it gets harder. You need to count

But for big numbers you can estimate how many quickly and accurately – go on, try it...*

*There are 35

THE POWER OF ONE

The loner mathematician is a popular, if exaggerated, image. But new studies suggest that in nature, mathematical skills and social skills are indeed a rare combination.

"Orang-utans approach solving problems very, very differently from chimpanzees and humans or even salamanders," says Robert Shumaker from the Iowa Primate Learning Sanctuary in Des Moines. He thinks that social pressures might explain why different species have evolved subtle differences in their number skills.

One of the most telling examples involves self-restraint. Say you present an animal with two piles of hard-to-resist food, such as gumdrops. If the animal picks the lesser of two piles of gumdrops, it earns a larger reward. Going for this delayed gratification requires a huge amount of self-control. Orang-utans can do it. Chimpanzees can't.

Primatologist Sally Boysen of Ohio State University in Columbus has trained chimpanzees to do almost everything else imaginable involving numbers. But picking less food is something the animals just cannot do. "If, instead of candy, I put Arabic numerals down, they didn't have any problem pointing to the number "2" instead of the number "5" immediately," Boysen says. "They knew the rules but they could just not inhibit going for the actual things. It's as if the number symbol freed them from this biological dictate."

Chimpanzees are extremely social animals, constantly competing for resources. They may just be hard-wired to pick more when it comes to food, regardless of what the trainers says. Rhesus monkeys and capuchins have the same problem, Boysen says, as do salamanders and pigeons.

Orang-utans, on the other hand, can pick the smaller of two quantities without any problem at all, says Shumaker. Unlike chimps, orang-utans tend to spend lots of time alone. Without pressure to compete, Shumaker says, they may have better control over their minds and actions. ●

"A detailed understanding of how the brain represents numbers could lead to more effective ways of teaching large numbers to children"

a cluster of cells that gives us an instinctive sense of small numbers. Either you have it or you don't (*New Scientist*, 3 July 1999, p 46).

He says that our brains have categories for "twoness", "threeness" and "fourness", just as they have categories for "greenness" or sharpness. For some reason, things change around five. Likewise, neuropsychologist Stanislas Dehaene, in his book *The Number Sense*, argues that a simple sense of number is as basic as a sense of colour. Both are useful ways for our brains to perceive the world. Advanced mathematics is more difficult, Dehaene says, because it relies on language and the ability to comprehend symbols.

All these theories scramble to explain some of the universal challenges that seem to come with large numbers. For example, it is much easier for both animals and people to distinguish between numbers when one is much bigger than the other. Thirty birds are obviously more than 15, for instance, while 15 and 14 birds can look the same at first glance. It is also easier to tell the difference between two and three things, for instance, rather than 49 and 50, even though the difference in each case is one.

The search to explain these basic effects has led to different theories about how the brain represents numbers. Does it have regions that know about discrete categories of "oneness" and "twoness", for example, as Butterworth and Dehaene suggest? How do we know about which order numbers appear in? And how do we manipulate numbers? One idea is that the brain creates some sort of map of different numbers. But there are two ways researchers think the map might appear. It could be that each number is given equal importance, and that they are spaced equally along a linear number line. As numbers get bigger, there are more to keep track of and so precision plummets. Another possibility is that the internal number line operates on a logarithmic scale: smaller numbers are dealt with more precisely and bigger numbers get more "compressed" in the brain, making it harder to tell them apart.

Results from behavioural experiments have failed to sort out which is the case, says Earl Miller, a cognitive scientist at the Picower Center for Learning and Memory at MIT. So he and colleague Andreas Nieder of the University of Tübingen in Germany went right to the source: individual cells in the brain.

Brain imaging studies had previously shown that an area called the prefrontal cortex becomes active when people think about numbers. And people with brain damage in that area lose their sense of number. So Miller and Nieder trained rhesus monkeys to judge whether consecutive images on a computer screen showed the same number of dots. Electrodes then recorded the activity of around 300 neurons in the prefrontal cortex as they carried out the task. Each image showed between one and five dots and to make sure the monkeys were using number to make their judgments, the dots had different sizes and positions.

The researchers found that different groups of neurons responded strongly to different numbers. Each individual neuron seemed to respond most strongly to one number. But they also showed exactly the property needed to form a number line, in that they "knew" something about the sequence of numbers before and after: a neuron's response would tail off as the number got bigger or smaller than its "favourite" number. So the responses of different groups of neurons overlapped. And when the researchers plotted exactly how much overlap there was, they found it was consistent with a logarithmic sequence.

Miller and Nieder are now working to pinpoint other brain areas and cells involved in recognising numbers. Already Nieder has unpublished data suggesting that a part of the brain called the posterior parietal cortex is the first area to respond when a monkey sees numbers. Next he wants to determine whether the same areas and cells respond when monkeys encounter numbers in other ways – by hearing different numbers of pulses, for example.

A detailed understanding of how the brain represents numbers could lead to more effective ways of teaching large numbers to children, Miller says. Seeing what works with animal training might suggest better ways to train kids in mathematical skills, for example.

He believes that understanding the general principles and mechanisms that the brain, particularly the prefrontal cortex, uses to categorise things by number, might eventually help us understand brain disorders where other forms of categorisation and conceptualisation go awry, such as schizophrenia, autism and attention deficit disorders. It's early days yet, he adds, but we might learn something about these very broad thought disorders by investigating how numeracy skills can go awry, and maybe even by testing how various brain chemicals affect how the brain learns and represents numbers in other animals.

For now, scientists are still trying to figure out just what animals can and can't do in order to delve deeper into our mathematical heritage. In a study published in *Nature* last April, for example, behavioural ecologist Bruce Lyon at the University of California, Santa Cruz, found that wild coots can count the eggs in their nests (vol 422, p 495). They then eject foreign eggs laid by other birds trying to offload their parenting responsibilities and add more of their own to compensate. "This was one of the very few studies showing counting in a wild animal as opposed to a laboratory setting," says Lyon. "So it connects counting back to the reason why they would be counting."

And Uller's next plan is to do her salamander study with shrimp and food pellets, to see if crustaceans will spontaneously go for more, just as babies, primates and salamanders do. "I'm going down the line here," she says. "We are not in the insect domain yet. A colleague suggested we try roaches – two breadcrumbs on the left, three on the right." She laughs. "We're not there yet." ●

A simple sense of number allows animals to tell instantly whether someone is missing

THOMAS MANGRLSON/MINDEN PICTURES

Emily Sohn is a science writer based in Minneapolis

Photographer: Rachel Lum

We're still waiting...

It can't be easy for someone who describes herself as a shy person to end up in the limelight as one of a tiny handful of women engineering professors in the UK and vice-president of the overwhelmingly male Royal Society. But for **Julia Higgins**, professor of polymer science at Imperial College London, it goes with the territory of fighting for a better future for women in science. **Wendy M. Grossman** talked to her

It's 2004, women everywhere are doing everything, yet you're still worrying about the position of women in science. Why?
Science shapes every aspect of our lives. If women are not well represented at every level then important things are lost. The number of women who stay in science in the UK and I suspect elsewhere in the west is still quite small. We have a huge problem with what Americans call the "leaky pipeline": women leaving science from PhD level upward.

What does get lost if women leave?
Women are missing out on really interesting careers, especially in technology and engineering. This is a great pity when you think of the many applications in engineering such as design and materials, all of which have a huge effect on women's lives.

Do women work differently?
About 25 per cent of the undergraduates in the chemical engineering department at Imperial are women. When you have a team working together there are usually one or two women in it – and those teams work differently and work better than the teams without them. They are probably less competitive, and they often have a broader view of the problems they are working on.

So how bad are the numbers?
In medicine, an amazing 73 per cent of graduates from British universities are women, but by the time they get to be professors it's more than a complete reversal, with women making up just over 11 per cent. In chemistry, women graduates amount to 40 per cent, but only 3 per cent of professors are women. Remember that's just 13. In engineering things are even worse. The graduate rate ranges from 8 per cent to 21 cent, but only 1 per cent of professors are women.

The career of Julia Higgins was definitely not planned, taking her from an early passion for physics and an Oxford degree, followed by an accidental move into the brand-new field of neutron scattering for her DPhil. Another unplanned opportunity gave her the chance to apply her knowledge, probing the properties of polymers, and set her on the path to become a professor of polymer science at Imperial College London, where she researches polymer "alloys". Among her many other "jobs" are vice-president of the Royal Society, chair of the UK Engineering and Physical Sciences Research Council, and president of the British Association for the Advancement of Science

Are there any disciplines where women professors outnumber men?
Nursing – 59 per cent of the total.

What about your field – polymers?
Polymer science is rarely a separate subject at undergrad level. But women do study chemistry and materials in large numbers – and a fair few who go on to research specialise in polymers.

Is that down to you as a role model? After all, you're a professor and vice-president of the Royal Society, with loads of prestigious initials after your name...
I wish it were! Yes, women do need women up there – and in numbers. But the truth about polymers is probably more to do with the perception that it is easier for women who want a career in science to go into a new area. Even so, at professorial level in polymers and similar fields, the percentage of women shrinks to around 3 per cent.

You started out in physics. Why was that?
I was at a girls' school, a Catholic convent grammar school, where the headmistress was a nun and a mathematician. When I was 15, a brilliant physics teacher joined the school, and suddenly science was fun and I could do physics. She was absolutely inspiring. I was a bright kid, so every time I said "Why?" she stopped and did it again, because if I hadn't understood it, then no one had. Having a good teacher along the line is crucial.

And your parents?
Both my parents were extremely keen on education for all their kids. All four of us have taken scientific directions. Neither of my parents was

a scientist. Apparently my father, who was a senior civil servant, said when I was born: "If she wants to go to university, she will." My sister is a maths teacher, one brother is an architect and the other did physics and works with computer systems.

How did you end up in chemistry?
I had done my physics degree at Oxford and was looking around for a place to do research. My tutor had a young friend in the chemistry department who had just come over from Australia and wanted to use this tool called neutron scattering to look at materials. He thought a young physicist might take more kindly to it than a chemist, so he interviewed me and offered a three-year place to move into the chemistry department. I hadn't done chemistry for five years at that point, and having to use a tool I had never heard of was daunting. I'd like to think it was curiosity that made me take the offer but I must say that my friends were staying in Oxford too.

Did you see it as an advantage to be entering a new field, where ideas hadn't become entrenched?
Yes in a way. But what happened was far more accidental. I don't believe you can plan research careers; they sort of happen. I got married after my DPhil and started teaching physics in a school, because I didn't know what else to do. I wasn't particularly good at it. Then after two years we moved to Manchester. My then father-in-law was working for the chemicals giant ICI there, and he gave me the name of a professor he knew. I wrote to him and he passed my letter on to another professor, who passed it on to a chemistry professor who wanted to use neutron scattering to look at polymers.

There are no careers in particle physics, my earlier love – papers have 42 authors. Neutron scattering wasn't being used in chemistry at all, and it certainly wasn't being used on polymers. I came in with the tool to look at the polymers, and very quickly the polymers became the research. But having that tool, which was unique, has been my passport all the way through.

What were your goals in those early days?
Early on in my career, I thought it would be wonderful to be a Fellow of the Royal Society. I didn't believe I would get there, but I did know what it would take. Could I get to be like that, I asked myself?

"The spirit of the times is to make sure that it's possible to have a career and be a woman rather than drop out"

Well you did but there are still only a few women among its members...
There are about 1200 fellows, and most live to a ripe old age. We elect around 40 a year, so it takes time to change. Over the past few years, we have been electing on average 10 per cent women – four out of the 40 – but this year we elected twice that many. I don't believe that's going to happen every year from now on. So now there are 53 women fellows. That's a rather higher percentage than women who are professors in some academic departments.

But at that rate you'll never get to parity...
Fortunately, some of the initiatives and schemes I'm involved with are going to make a difference. The Royal Society has a large amount of money that it puts into university research fellowships to very bright young people in their early 30s. This gives them up to 10 years in a university doing research. After that they usually go on to become professors almost immediately. The RS also invented the Dorothy Hodgkin Award, which kicks in before the research fellowships. They last for four or five years, but they are yours, they are not linked to a departmental project. We never said explicitly that these were aimed at women, but that they were aimed to be "family friendly", providing maternity leave, and so on. The extraordinary thing was that 90 per cent of the applicants were women: the moment it said things like "family friendly", they read "women". Interestingly, of the incoming applicants for research fellowships at least half are women so this has also turned out to give women a good start in a research career because it's quite flexible. Most recently, we introduced a "follower's fellowship", aimed at two-career families in which one partner moves job. The partner who has to follow can get a fellowship for a year to hold in the new place. It can work for both sexes but we suspect it will be more used by women. We'll have the cash for about 10.

Outside the Royal Society, what of Athena?
Athena was given £250,000 of government money aimed at helping recruit and hang onto women in university academic careers, using the involvement of vice-chancellors and the great and the good to ensure high visibility. It gave small awards to centres of excellence with good practice for women.

The government has also just said it would put £5 million into coordinating these small initiatives through a central resource unit. Is this enough?
I'm not sure that throwing more money is the whole answer. What matters is support and real enthusiasm – and our male colleagues won't always give that, so the only way you are going to get something done is by supporting the women who are already there. Frankly, most of us aren't prepared to spend all our lives doing that. So you have a problem. That said, quite clearly more needs to be spent on part-time working – and spent in quite specific ways.

What about the next generation?
I think they think in terms of having a career and family. Research chemist Susan Gibson, who has just won the first Rosalind Franklin award of £30,000, is a good example of someone

doing great science who happens to have two kids under 5. This is an award for a rising star rather than for women alone, and it is there to be spent on the winner's research, not their salary, and on promoting women.

So do you disagree with Susan Greenfield when she talks about it not being possible for women to combine children and science if they want top jobs?
I certainly don't think young women see it that way, though the middle ranks may. The problem really lies with breaks in research. The thing about research is you have to have a certain sort of mind. You have to be a bit driven. You are constantly putting yourself up against not knowing the answer. In some ways, research has to be uncomfortable, so it's actually quite hard, and there is only a subset of people who really like doing it.

Does this mean fewer women than men make good researchers?
Absolutely not. But it is my observation that when women are at an age when they are making choices, they have less self-confidence than men about how good they are at everything. You constantly see women undersell themselves. Research is quite hard: you are constantly measuring yourself against the outside. You send off papers to a journal, which may well come back with "Reject" marked on them. That's hard to take. You send off a grant proposal which you may or may not get. So you need people and structures to build up your confidence. I was very lucky that the people I worked with were always saying, "Yes, go for it."

Is some of the drop-out rate to do with not having the same sense of entitlement to a career that men have?
There is no doubt that the spirit of the times is to make sure it's possible to have a career and be a woman rather than drop out. I do think that young women now should demand that.

Would it have turned out differently if you had had children?
I can't tell you what would have happened had I had children, it wasn't a conscious choice. It happens to have turned out that way. I have a wonderful time with my eight nieces and nephews, who all live close to me. ●

Antipodes

Scientific justice

Ian Lowe considers how to deal with research fraud, and the regulation of therapeutic products

DOES Australia need a scientific ombudsman to investigate cases of misconduct or possible fraud? The decision in the Hall case—recently released by the University of New South Wales–has put the issue squarely on the political agenda.

The case has a long history, much of which is outlined in a report by the university's vice-chancellor available at *www.vc.unsw.edu.au/Reports/External.shtml*.

More than two years ago, three scientists working with transplant immunologist Bruce Hall accused him of scientific misconduct. Among the allegations they made—and detailed in the report—are that a published paper "contained data and statements for which there were no supporting experiments" and that a grant application also made claims for which there was no supporting data.

After an internal inquiry, the university set up an external panel including three distinguished medical researchers, and chaired by former High Court chief justice Sir Gerard Brennan. When the inquiry was completed last January, Hall obtained an injunction to prevent public release of its report. The findings were reviewed by incoming vice-chancellor Rory Hume, himself formerly a professor of dentistry with research experience in immunology.

Hume sought advice from experts in the field before reaching his conclusions. In the interesting words he used in a recent article written for *The Australian*, Hume says he found Hall guilty of "academic misconduct, but not scientific misconduct" with respect to five of the six allegations. He dismissed the sixth allegation. Hall was censured for two of those instances of misconduct. And the three whistle-blowers were left to ponder their future.

Some of the media comment has been hostile. Writing in *The Australian*, science editor Leigh Dayton said that Hume had "supported the powerful researcher at the expense of the weak" and that the case proved that "Australia needs a scientific ombudsman".

Science lobby group the Federation of Australian Scientific and Technological Societies (FASTS) gave the idea cautious support. President Snow Barlow said that such a role would take the pressure off decision-makers like Hume. Science minister Peter McGauran was less enthusiastic, while the Australian Academy of Science was opposed, with President Jim Peacock saying, "The last thing we need is another commission".

The case does raise serious issues about the position of a university vice-chancellor or the head of a research institute faced with allegations of serious misconduct. Not only do these people have to consider the reputation of their institution, they also usually have to work within the rules of local enterprise agreements, with entirely reasonable provisions designed to protect individuals from unjust treatment.

An outside office, such as that of a scientific ombudsman, would at least mean that justice was seen to be done.

RECENT agreements between Australia and New Zealand will result in big changes to the advertising and sale of therapeutic products. NZ will join Australia in banning direct consumer advertising of prescription drugs. And a joint scheme to regulate all therapeutic products in both countries, including complementary medicines and over-the-counter items, will come into force next year.

NZ was the only developed country, apart from the US, to allow advertising of prescription medicines (Antipodes, 19 April, 2003). Now that will change. But the new trans-Tasman agency to regulate therapeutic products is an even bigger step. It will come into force in July 2005. Announcing the move, NZ health minister Annette King noted that at present food is more strictly regulated than alternative therapies.

ENIGMA 1273

Unless

Keith Austin

That great artist Pussicato has painted a picture containing antelopes, bears, cats and dogs. For aesthetic reasons he kept to the following conditions:

Writing a for the number of antelopes in the picture, b for the number of bears and so on:

$a+6d=2b+c+20$ unless $a+6d=2b+c+17$; $a+d=b+2c+2$ unless $a+d=b+2c+1$; $3a+5d=3b+5c+11$ unless $3a+5d=3b+5c+12$; $3b+5c=2a+2d+1$ unless $3b+5c=2a+2d+3$; the total number of animals is odd unless it is divisible by 5.

How many of each animal are there in the picture?

£15 will be awarded to the sender of the first correct answer opened on Thursday 26 February. The Editor's decision is final. Please send entries to Enigma 1273, New Scientist, 151 Wardour Street, London W1F 8WE, or to enigma@newscientist.com (please include your postal address). The winner of Enigma 1267 is Ian Adamson of Little Bealings, Woodbridge, Suffolk, UK.

Answer to 1267 Prime progression
George's smallest number and common difference are 199 and 210.

River deep, mountain high

MARY EVANS

On 22 April 1805, Captain Meriwether Lewis was hiking the bluffs of the Missouri river near present-day Williston, North Dakota. Sixty metres below him, other members of the Lewis and Clark expedition were waiting for strong headwinds to die down so they could continue their laborious journey upriver. Lewis decided to explore on foot. As he walked, he spied an outcrop of polished rock, strewn with pebbles that were smooth and worn, as though tumbled in a mountain stream. Lewis concluded that the water had once been all the way up there. We now know that Lewis's ancient beach was created a million years ago, before ice-age glaciers blocked an earlier river and forced the Missouri to carve its present, much deeper, valley. But geologists are astounded that Lewis, with no knowledge of ice-age phenomena, realised how the ledge was formed. It is one of many spot-on deductions that reveal that he and William Clark were remarkably good intuitive geologists.

IN THE early 19th century, geology was barely a science. There were no grand theories, no concept of the processes that build mountains, barely an inkling of the geological timescale and the meaning of fossils. But in 1803, when President Thomas Jefferson ordered an expedition to explore the vast Louisiana territory that the US had just bought from France, he could not have picked better geologists to lead it than Meriwether Lewis and William Clark. From March 1804 to September 1806, the two men kept their eyes peeled, took meticulous notes, and drew conclusions that often required a great deal of insight. It is only now, two centuries after they set out, that geologists are beginning to recognise their accomplishments.

For generations, the explorers were maligned by historians, who gave them credit for wonderful descriptions of botany and geography but dismissed their geological observations as worthless. "These historians didn't realise they were reading geology in the journals of Lewis and Clark," says John Jengo, a consulting geologist from Downingtown, Pennsylvania, who has been fascinated by the expedition for 25 years. "In very simple phrases, Lewis and Clark communicated concepts that are obvious to a geologist."

One of the expedition's more interesting discoveries was finding the source of the "pumice" that earlier explorers had seen floating far down the Missouri river. Reports of the floating stones may even have reached Jefferson, who – perhaps worried that he'd bought nothing but a vast, lava wasteland – had specifically instructed the explorers to keep an eye out for volcanoes.

In the spring of 1805, Lewis and Clark traced the stones to outcrops in the river bluffs of western North Dakota. Then, in one of those intuitive flashes that typified the explorers' geological acumen, Lewis realised that the "pumice" was found only in gaps in coal seams – and that this meant their origins had nothing to do with volcanism.

At the time, nobody knew why rocks formed in layers, but Lewis and Clark clearly understood that strata could be traced from one outcrop to another. Lewis observed that the pumice occurred only where there should have been coal, and that where there was pumice, there was no coal. He correctly concluded that the pumice-like rocks were formed when coal seams caught fire and cooked the overlying rock into something that we would call clinker.

"The explorers' journals provide a unique, enormously detailed snapshot of the land before America's westward expansion"

He showed similar insight when he penned one of the earliest known descriptions of petrified wood. "I met with several stones today that had the appearance of wood first carbonated and then petrefyed by the water of the river," he wrote. Not only is this description perfect – the petrified wood of the western Dakotas is made of coal beneath a surface that looks so much like wood that it is possible to mistake it for weathered timber – but Lewis was also close to the mark in describing the process that formed it. The main thing he missed was that the wood was petrified not by river water but by the slow action of percolating groundwater.

Elsewhere in their journals, Lewis and Clark correctly inferred that muddy tributaries of the Missouri had their sources on the Great Plains, while clear water sprang from the mountains. When they reached the mountains, The Geological Society of America included a symposium on the Lewis and Clark expedition at its annual meeting in Seattle last November

they reported "shattered, confused, and broken masses of stone", and hillsides "that appeared to be broken by some convulsion" – not a bad description of the faulting processes now understood to have formed them.

Another major observation came on the Columbia river, slightly upstream of the present-day Bonneville dam. Here, the explorers found a calm pool of water in which the trunks of dead firs rose out of water 6 metres deep. Aware that the trees couldn't have grown in the water, Clark figured that something must have dammed the river and flooded the forest that once cloaked its banks. He also noted that the current was curiously sluggish – a sure sign to experienced river runners of large rapids lurking downstream. When their boats finally reached the swathe of boulders that had blocked the river and created the rapids, Clark speculated that it had been formed by a gigantic landslide.

Generations of subsequent geologists were to stare at the same rapids and offer conflicting explanations. Some said the dam was produced by tectonic warping or slippage along a fault line. Others thought it was a glacial moraine, debris dumped by a vanished glacier. The debate raged until 1916, when it was confirmed that Clark's off-the-cuff answer had been the right one.

Present-day researchers have also begun to realise that the explorers' journals provide a unique, enormously detailed snapshot of the land before America's westward expansion. Specialists in many fields are now using that information to determine exactly how the land has changed. Some of their findings are surprising.

Conventional wisdom has it, for example, that 20th-century flood-control projects on the Missouri river increased its current by funnelling water more swiftly downstream. Not so, says Dale Blevins, of the US Geological Survey in Lee's Summit, Missouri. Clark measured the river's current by anchoring a boat in mid-channel, tossing overboard a log tethered to a rope, and timing how long it took for this "log line" to pay out. Presuming that the rope was the standard 50-fathom (91-metre) line generally used for this purpose, Blevins calculates that the currents Clark measured flowed at speeds of between 9 and 16 kilometres per hour. That is slightly faster, not slower, than those seen at the same locations today. This finding is important to conservationists attempting to save endangered species of fish because it reveals the natural conditions to which these species were adapted.

Clark also measured the river's sediment load. An old joke holds that the untamed Missouri river was "too thin to plough, too thick to drink". In fact the expedition did force down its muddy waters. "The water we Drink... contains half a Comn Wine Glass of ooze or mud to every pint," complained Clark. Leaving aside the question of why the expedition carried a wine glass, Blevins (after researching the size of wine glasses in 1804) concludes that the water must have been 4.5 per cent sediment. Modern sediment levels never exceed 1.5 per cent. Where did all that mud come from? Clark reported that the fast-moving river was eroding sharply into its banks at each turn.

Alex Philp, who develops software for geographical information systems, believes that modern researchers have barely begun to dig information out of Lewis and Clark's journals. Their expedition took place as the Little Ice Age was ending, and the explorers' meteorological observations and detailed river descriptions provide an untapped source of data for observing the effects of a change of climate on two of North America's greatest river basins: the Missouri and the Columbia. Even the plant specimens they brought back provide useful clues. These samples still exist, and researchers have begun to analyse isotopes in their tissues to determine growing conditions and atmospheric conditions in the regions where they were collected.

This type of data may be Lewis and Clark's greatest contribution to science. "Our understanding of the Earth changes, but as long as someone made very clear observations, you can always get useful information from them," says Edward Murphy, author of a guidebook to a portion of their route. "What surprises me is what good observers Lewis and Clark were. That has always been one of the best traits a geologist can have." **Richard A. Lovett** ●

ED MURPHY/NORTH DAKOTA GEOLOGICAL SOCIETY

The Missouri just downstream from Williston, North Dakota, is now flooded by Lake Sakakawea

GETTY

Weigh to go, Solly

The Tale of the Scale
by Solly Angel, Oxford University Press, $28, ISBN 0195158687
Reviewed by Roy Herbert

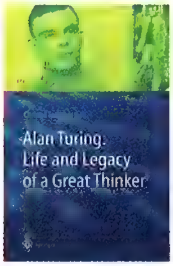
JET-LAGGED, Solly Angel sat in his hotel room in Bangkok and stared at the bathroom scales. They seemed to him a thing of no elegance – clumsy, inaccurate. Surely they could be improved. They could be beautiful, slim and precise, an instrument anyone would be proud to own and, furthermore, portable. In Hollywood, what followed would have been called A Lone Man's Battle to Make His Dream Come True.

Angel, an authority on urban planning, had no idea how scales worked. The rest of the book is about his staggering perseverance to become an expert on the technology of weighing and finally a designer of wonderfully efficient and cheap load cells, and his tussles with bad faith, lack of money, wrestling with patent law, constant disappointment and the complicated tactics of big business, all this while carrying on his original profession across the globe. There is a danger that his travails could seem bathetic, much ado about something as mundane as improving bathroom scales. Who cares?

Against the odds, Angel makes *The Tale of the Scale* interesting. His determination is impressive. His sense of humour stays alive even in the direst circumstances and he is easy to identify with. His early vision of making a million dollars soon fades, but this doesn't stop him. A rueful book, and a much more rewarding read than might be supposed.

Dead right

Alan Turing
edited by Christof Teuscher, Springer Verlag, £46/$69.95, ISBN 3540200207
Reviewed by Mike Holderness



ON 7 June 1954 Alan Mathison Turing took a bite from an apple laced with potassium cyanide. You should mark the 50th anniversary of his death, and a fitting way would be to finish this Festschrift that came out of a 2002 celebration of the 90th anniversary of his birth. You may have to start soon, however, because, like Turing, the book is difficult.

In 1936 Turing published arguably the deepest result in mathematics or logic to date. Loosely, it is that there is no such thing as a mathematical checker of mathematical theorems. In order to achieve this feat of meta-mathematics he needed to define "calculate", and his answer was the theoretical underpinning for computers and of computability.

What is not so well known – and is discussed in detail here – is that he also founded the study of neural networks. Moreover, he laid the foundations for our understanding of how genes can control growth and structure.

Other contributions range from memoirs filling in details of his time breaking military codes at Bletchley Park in the 1940s to speculations about "hypercomputing" – calculating that which he proved to be incalculable. Alarmingly, some of the latter seem to depend on mediaeval-style appeals to authority: specifically that in his 1939 PhD Turing discussed an "oracle machine". Re-reading that, this is clearly mathematical sarcasm. The more entertaining contributions involve programs that require infinite memory and dropping computers into carefully chosen black holes.

Books reviewed next week include:

- ● Quaking star
- ● Serendipity
- ● Death

What, asks biographer Andrew Hodges, would Turing have done had he lived longer? He would have continued investigating the intersection of mathematics and biology – and quite likely extended this into evolution, inventing chaos and fractals in a moment of boredom on the way. Then imagine him in 1967, when his sexuality was finally decriminalised in the UK...

Mike Holderness is a geek and proud of it

Dinotopia

African Dinosaurs Unearthed
by Gerhard Maier, Indiana University Press, £37.95, ISBN 0253342147
Reviewed by Douglas Palmer

ALL dinosaur fans will have heard of Tendaguru in German East Africa (today's Tanzania) and its famous giant sauropod – *Brachiosaurus*. Black-and-white photos of the huge skeleton mounted in the Natural History Museum in Berlin have graced popular books on fossils ever since 1937 when it first went on public display.

It was more than 30 years earlier, in 1906, that German mining geologist Benhard Sattler first spotted large bones near Tendaguru. And what most people do not realise is that Berlin's giant dinosaur was not alone.

Gerhard Maier's *African Dinosaurs Unearthed: the Tendaguru expeditions* details exactly how one of the world's biggest caches of dinosaur fossils was excavated and recovered. Successive German expeditions in early 20th century dug out the lion's share – 185 tonnes of fossil bones in 824 crates had been taken to Germany by the end of 1911. The expertise and labour of more than 5000 Africans made it all possible. But this is only the beginning of a fascinating story well told by Gerhard Maier, a professional palaeontologist who really knows what he is writing about.

The second part of the saga begins after the first world war, when Arthur Smith Woodward of the then British Museum (Natural History) decided that it was time the Brits got in on the action because all German settlers had been expelled from the territory, which was by then imperial pink.

By 1926, another 17 tonnes of dinosaur bone had been recovered from Tendaguru, this time shipped to London. By 1930 even more had been added.

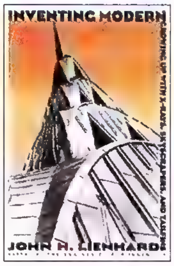
Maier reckons the British spent about £11,000 altogether, comparable to the total cost of the German expeditions, and yet "one of the most obvious differences between the German and British expeditions was that the latter did not publish its scientific results". Although strapped for cash, the Natural History Museum is even now trying to unpack and conserve its African dinosaurs.

Incidentally, one 20-year-old member of the 1924 British expedition was called Louis Leakey, who subsequently met Hans Reck, a member of the German expeditions, who knew of a particularly interesting locality for fossils called Olduvai Gorge. But that's another story.

Douglas Palmer is a palaeontologist based in Cambridge

Now is then

Inventing Modern
by John Lienhard, Oxford University Press, £13.99/$28, ISBN 0195160320
Reviewed by Wendy M. Grossman



"MODERN" meant "now" when I was growing up. For John Lienhard, "modern" means the first half of the 20th century, when change came in a furious rush: electricity, aeroplanes, quantum mechanics, art deco and skyscrapers.

Lienhard's history of modern links disparate developments that normally never appear in the same book. Automobiles, for example, brought with them roadside advertising, fast food and urban sprawl.

Where did modern go? Lienhard says it ran out of steam, and digital overtook it. Now, he hopes we can recover its lost hope and mystery.

Wendy M. Grossman is a technology writer

Rocket man

Robert Stephenson
edited by Michael Bailey, Ashgate, £55, ISBN 0754636798
Reviewed by Mick Hamer

ALTHOUGH George Stephenson was known as the father of the railways, and celebrated on the old British £5 note, his son Robert had a better claim to have begotten the railways. It was Robert who designed *The Rocket*, the steam locomotive that won the Rainhill Trials of 1829.

But Robert was much more than just a mechanical engineer. He was also a civil engineer: routing railways and building tunnels and bridges.

By 1850 Britain had built nearly 11,000 kilometres of railways, and Stephenson had played a part in a third of these schemes. He was a consulting engineer in America, Europe, Egypt and India. He also advised other countries such as Sweden , Denmark, and Switzerland to draw up a strategic plan for developing their railways.

This was engineering on an heroic scale, and such was his fame that thousands lined the route of his funeral when he was buried in Westminster Abbey in 1859. But as time passed the fame that he enjoyed in his life has subsided, and this comprehensive volume, edited by Michael Bailey, is the first full-length biography of him since 1864. ●

WHO'S READING WHAT

Peter Agre

2003 was a brilliant year for Peter Agre, professor of biological chemistry at Johns Hopkins University in Baltimore. He won the Nobel prize for chemistry for his discovery of water channels in cell membranes. Agre enjoys histories and biographies: his latest read is David Halberstam's *The Best and the Brightest* (Random House, 1972), about the White House during the Kennedy and Johnson administrations. "Despite formidable talent," Agre says, "their advisers got it wrong, causing the 10-year debacle in Vietnam. This brings new perspective to the Bush government in Iraq."

"Exhilarating and depressing" is Agre's verdict on Roland Huntford's *Nansen* (Duckworth, 1997), a biography of "Norway's greatest explorer and statesman", Fridtjof Nansen. Though extremely courageous, Agre says, Nansen was dreadful to his family.

Matthew Josephson's *The Robber Barons* (Harcourt, 1934), about capitalists Jay Gould, J. P. Morgan, Andrew Carnegie and their contemporaries, "makes the current Enron executives look like minor-league crooks", says Agre.

Kristin Bowman-James

Another chemist in the headlines is Kristin Bowman-James, professor of chemistry at the University of Kansas. She received two awards in 2002, from the Iota Sigma Pi (national honour society for women in chemistry) and the American Chemical Society – for encouraging women to enter the discipline. Her reading reflects this: she loves novels with women protagonists or at least women in the main roles, as well as suspense and intrigue, and fast-paced novels, "especially if there is some science in them as well". So she has particularly enjoyed *Final Target* by Iris Johansen (Macmillan, 2001).

"Most of the time I only read when travelling," she admits. On a recent trip back from Oak Ridge, Tennessee, she started James Patterson's *Second Chance* (Little Brown, 2002), another novel in which the women are key players and science is involved. She is finding it "absolutely riveting": "I even had trouble putting it down when we landed."

Transatlantic takeovers of Europe's biotechs will continue unless European investors take stock

The perils of undervaluation

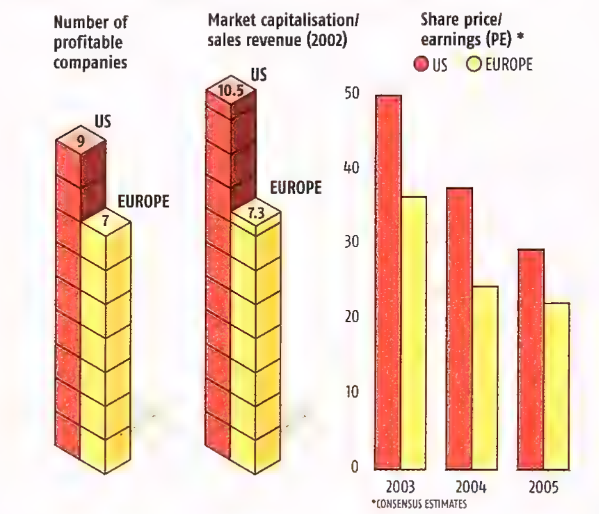
Keith Redpath is head of life sciences research at European investment bank Panmure Gordon, a division of Lazard

DO EUROPEAN stock markets really know the value of life science companies? Recent transatlantic takeovers of European biotech companies have left some investors wondering what American purchasers can see in the pipeline that European investors are ignoring.

Look at some of last year's takeovers. In October, US giant General Electric bid for UK healthcare company Amersham, offering 800p per share when the shares stood at 550p in the market. This bid came hot on the heels of UK-based vaccine company PowderJect's acquisition by the US biotech Chiron for 550p per share. PowderJect's shares had been around 260p before bid rumours started only six months earlier.

Shareholders were no doubt delighted by their short-term gains. But in the long run, the low value that European investors place on companies compared with their US counterparts will have damaging consequences.

TOP 10 US & EUROPEAN BIOTECH COMPANIES (AT 5 JANUARY 2004)



*CONSENSUS ESTIMATES

● US top 10: Amgen, Genentech, Biogen, Gilead Sciences, Genzyme, Chiron, Medimmune, Millennium, Applied Biosystems, Celgene

○ Europe top 10: Serono, Shire, Actelion, Celltech, Qiagen, SkyePharma, Flamel, Acambis, deCODE genetics, Alizyme

SOURCE: PANMURE GORDON

So why do American and European investors see things so differently?

It all boils down to the way that investors work out the value of companies. The usual approach for a company that is not generating a profit – which means most European biotech companies – is to build a 10-year forecast, accounting for money coming in and cash burn, in what's called a discounted cash flow (DCF) analysis.

But there are problems with these models. Many biotechs are years away from a product launch and revenue generation, and forecasting likely product revenues in, say, 2007 is at best an educated guess. A difference in a royalty fee of 10 or 15 per cent on sales worth $1 billion can translate into a major difference in valuation. When the company has yet to secure a deal, who's to say which number is right?

As a result, share prices are often driven by investor sentiment towards these companies, and individual views as to whether the products in R&D will eventually deliver profits. US investors have a greater appetite for risk in the sector, so their valuations of up-and-coming companies tend to be higher.

In theory things should be simpler once a company turns profitable and the stock market can revert to measures it understands better. "Normal" valuation criteria can be applied, rather than DCF analyses or some other mathematical approach to valuation. With positive earnings, financial benchmarks such as the ratio of share price to earnings (PE) are used to compare the performances of different companies. But this is far from straightforward, especially when a company reaches its first year of profits.

If a company posts modest maiden profits, the relatively small size of its profit compared to share price makes the company look expensive for a prospective investor. In 2003, for example, medium-sized European healthcare companies traded at around 18 to 28 times their earnings, but PowderJect had a PE of around 200 at its takeover price. Judged on simple financial benchmarks, PowderJect looked like a bad bet.

But these simplistic calculations ignore the potential for growth in the emerging company, and the value of products that are not yet delivering earnings. Whereas larger life science companies struggle to deliver growth in double digits, emerging companies in the sector can and do deliver 20 to 30 per cent growth in earnings year on year. Chiron obviously made its decision to purchase PowderJect with these factors in mind rather than its PE.

US investors seem to look beyond these simplistic financial models, and take a longer-term view. They include the future returns from today's R&D projects in their view of an emerging company. Perhaps this difference in attitudes is not surprising. The US biotech sector is about 10 years older than Europe's, so investors have seen more companies break through to profitability, boosting confidence in their ability to deliver.

The effect of this undervaluation is that transatlantic raids will continue. Shares in US biotechs trade at a significant premium to the European sector (see Graphic). This extra financial clout allows US companies to snap up their European cousins at a premium to market and enhance the integrated company's earnings per share from day one.

In the longer term, it is European industry and its investors that lose out. Accepting a bid at a 40 per cent premium to market looks attractive today, but what might the company be worth in the future? How high could the share price go? Unless European investors gain an appetite for more risky investments, this transatlantic discontinuity will remain, and Europe will lose its best biotech companies to the US. ●

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Closing date: 10 Apr 2004

Further information:
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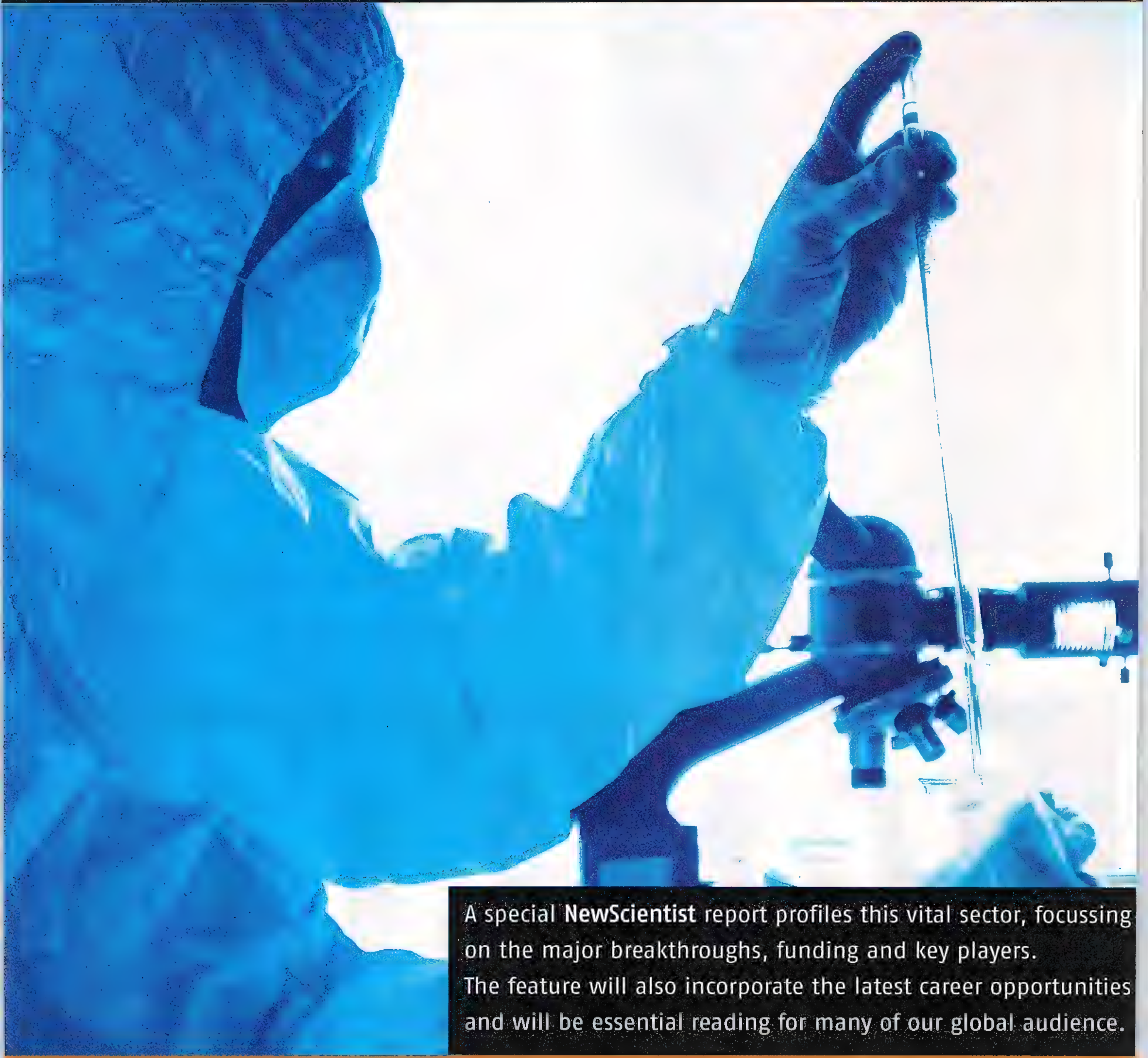
AUSTRALIAN BIOTECHNOLOGY 1 MAY 2004



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Australian Government

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Applicants must address the selection criteria in their application. The application should include qualifications, experience, and two referees. A PhD or equivalent is required.

Forward applications by close of business 30 January, 2004.

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Research Assistants (Two Posts) - Experience in Molecular Biology is Required (Ideally DNA and RNA Extraction, PCR, Southern, Northern and Western Blots Etc.)
University of Cambridge, Department of Clinical Biochemistry
Cambridge, Cambridgeshire
£18,265 £20,311 pa
NS200253100055

Research Assistants (Two Posts) - Responsibilities Will Include Census and Record Keeping, DNA/RNA Extraction and Genotyping
University of Cambridge, Department of Clinical Biochemistry
Cambridge, Cambridgeshire
£18,265 £20,311 pa
NS200253100056

Postdoctoral Research Associate
Royal Veterinary College (The)
London
Starts £20,311 per annum, plus £2,134 per annum London Allowance
NS200253100058

Research Technician
University of Leicester
Leicester, Leicestershire
£15,053 to £17,880 pa
NS200253100065

Research Technic
Liverpool School of Tropical Medicine
Liverpool, Merseyside
Salary within the range £15,053 £17,880 (Grade D) £18,409 £20,755 pa (Grade E)
NS200253100066

Lectureship in Pharmacognosy/ Natural Products
University of Bradford
Bradford, West Yorkshire
£22,125 £33,679 per annum
NS200253100067

University Biological Safety Officer
University of Oxford
Oxford, Oxfordshire
£30,660 £36,712 p.a.
NS200253100069

MRC and EP Abraham Research Studentships - Macrophage Differentiation in Atherosclerosis
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370006

MRC and EP Abraham Research Studentships - Protein Sorting to the Immunological Synapse
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370007

MRC and EP Abraham Research Studentships - Nuclear Structure and Antigenic Variation in African Trypanosomes
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370008

MRC and EP Abraham Research Studentships - The Role of Dendritic Cells in Immunity to Eimeria Nieschulzi in the Rat
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370009

MRC and EP Abraham Research Studentships - Dissecting the Role of the Ctd of Polymerase II in Expression of the Human Snrna Genes
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370010

MRC and EP Abraham Research Studentships - Investigation of the Molecular Mechanism of Int6Induced Drug Resistance
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370011

MRC and EP Abraham Research Studentships - Regulatory T Cells in Mucosal Immunity
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370012

MRC and EP Abraham Research Studentships - Molecular Analysis of T Cell Antigen Recognition
University of Oxford, Sir William Dunn School of Pathology
Oxford, Oxfordshire
NS20025370013

MSc in the Molecular Biology and Pathology of Viruses
Imperial College Of Science, Technology And Medicine
London
NS20025370025

Research Assistants (Two Posts) - Experience in Molecular Biology is Required (Ideally DNA and RNA Extraction, PCR, Southern, Northern and Western Blots Etc.)
University of Cambridge, Department of Clinical Biochemistry
Cambridge, Cambridgeshire
£18,265 £20,311 pa
NS200253100055

Research Assistants (Two Posts) - Responsibilities Will Include Census and Record Keeping, DNA/RNA Extraction and Genotyping
University of Cambridge, Department of Clinical Biochemistry
Cambridge, Cambridgeshire
£18,265 £20,311 pa
NS200253100056

Postdoctoral Fellowship
University of Exeter
Exeter, Devon
Salary will be in the range £18,265 p.a. £20,311 p.a.
NS200253100057

Postdoctoral Research Associate
University of Leicester, Department of Chemistry
Leicester, Leicestershire
£18,265 to £27,339 pa
NS200253100064

Research Technician
University of Leicester
Leicester, Leicestershire
£15,053 to £17,880 pa
NS200253100065

Research Technic
Liverpool School of Tropical Medicine
Liverpool, Merseyside
Salary within the range £15,053 £17,880 (Grade D) £18,409 £20,755 pa (Grade E)
NS200253100066

Programme Manager in Nanotechnology
University of Oxford
Oxford, Oxfordshire
£25,451 £33,679 p.a.
NS200253100059

Research Assistant
University of Bradford
Bradford, West Yorkshire
£18,265 £20,311 per annum
NS200253100068

Senior Instrumentation Engineer (Team Leader)
University of Oxford, Department of Materials Electron Microscopes Technical Support Team
Oxford, Oxfordshire
Grade RSII: £25,451 £33,679 p.a.
NS20025370003

Senior Electron Microscope Support Technician
University of Oxford, Department of Materials Electron Microscopes Technical Support Team
Oxford, Oxfordshire
Technician grade F: £21,414 to £23,296 p.a.
NS20025370004

MSc in High Performance Computing
University of Edinburgh
Edinburgh, Scotland
NS200253100078

Residential Teaching Posts
Open University (The)
Milton Keynes, Buckinghamshire
NS20025370005

Research Assistant
University of Bradford
Bradford, West Yorkshire
£18,265 £20,311 per annum
NS200253100068

Research Assistant
Imperial College London
£20,399 - £22,445 inclusive of London Weighting
NS20032415157

Lecturer/Senior Lecturer/Reader (3 Posts)
University of Sheffield, Department of Animal & Plant Sciences
Sheffield
£22,191 - £39,958 pa
NS20032415138

Lecturer/Senior Lecturer/Reader in Biomedical Science (4 Posts)
University of Sheffield, Department of Biomedical Science
Sheffield
£22,191 - £39,958 pa
NS20032415137

Lecturer/Senior Lecturer/Chair (5 Posts)
University of Sheffield, Department of Molecular Biology and Biotechnology
Sheffield
£22,191 - £39,958 pa
NS20032415136

Research Assistant
The University of Manchester
Manchester
£18,265 - £20,311 p.a. (under review) depending on experience
NS20032415134

Research Assistantship
University of Wales Institute, Cardiff
£11,962 pa
NS20032415131

Postdoctoral Molecular Pharmacologist/Biochemist
The School of Pharmacy University of London
Up to c. £24k including London Allowance
NS20032415130

2 Scientists - Synthetic Organic Chemists
The School of Pharmacy University of London
Up to c. £22.5k
NS20032415129

Postdoctoral Synthetic Organic Chemist
The School of Pharmacy University of London
Up to ca £26k including London Allowance
NS20032415128

Postdoctoral Research Fellow in Mammalian DNA Replication
University of York Department of Biology
York
Up to £23,296 p.a. (pay award pending)
NS20032415125

Database Assistant (ORS1)
Imperial College London Division of Primary Care and Population Health Sciences
£18,265 to £22,191
NS20032415124

Database Manager (ORS3)
Imperial College London Division of Primary Care and Population Health Sciences
£28,498 to £29,621
NS20032415123

Ancillary Unit Manager
University of Sussex
Brighton
£21,125 to £27,339 pa or £28,498 to £33,679 pa
NS20032415122

Chair or Senior Appointment in Medical Statistics and Epidemiology
London School of Hygiene & Tropical Medicine,
NS20032415115

Postdoctoral Scientist
University of Edinburgh
Edinburgh
£18,265 - £27,339 p.a. (under review)
NS20032415114

Research Fellows: Post 2
University of St Andrews
St Andrews
£18,265 - £27,339 pa
NS20032415112

Technician
University of Leicester, Department of Cell Physiology and Pharmacology
Leicester
£12,997 to £14,581 pa
NS20032415110

Research Technician
University of Leicester, Departments of Cardiovascular Science and Genetics
Leicester
£15,053 to £17,880 pa
NS20032415109

Research Technician
University of Leicester, Departments of Cardiovascular Science and Genetics
Leicester
£15,053 to £17,880 pa
NS20032415108

Senior Epidemiologist
Veterinary Laboratory Agency
Surrey
&#163;33,500 - &#163;51,275 per annum
NS20032415024

Research Assistant
Cambridge University
Cambridge
£18,265 - £20,311 pa
NS20032414084

Postdoc research assistant
Kings College London/St George's Hospital Medical School
£26,255 pa inclusive of London Allowance
eur1420

Molecular Biologist
University Of Edinburgh
Edinburgh
£18,265 to £27,339
eur1412

Research assistant
University of Leicester/ILeicester and Warwick Medical Schools
Leicester
eur1410

PhD Studentship
Kings College London
Stipend is £12K/year for 3 years
NS20032415139

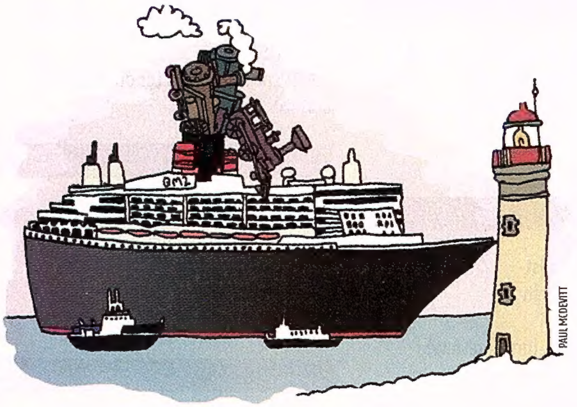
2 Scientists - Synthetic Organic Chemists
The School of Pharmacy University of London
Up to c. £22.5k
NS20032415129

Postdoctoral Synthetic Organic Chemist
The School of Pharmacy University of London
Up to ca £26k including London Allowance
NS20032415128

Research Assistants/PhD Opportunities (3 posts)
Cranfield University
Beds
£11,000 to £13,500 p.a.
NS20032415120

Senior Technician - Analysis/Environmental Chemistry
Cranfield University
Beds
£15,568 - £18,585 p.a.
NS20032415119

Feedback



PAUL MCDEVITT

INSPIRED by observations here about silly comparisons, a colleague has presented Feedback with a whole book of them – "but be careful with it, it's for my Mum". The *Queen Mary 2 Book of Comparisons* (Cunard, ISBN 095424513X) reprints parts of *The Queen Mary – a Book of Comparisons*, published in 1936. So now we know that though one funnel of the old one could accommodate three US-gauge steam locomotives, the sole exhaust thingy of the new one is big enough for four Eurostar trains (disappointingly, widthways only). Our favourite so far: the weight of the old one would need a freight train 40 miles long to move it, whereas the new one weighs more than "a school of 330 blue whales". Is that before or after a hearty krill lunch?

THE White House was very keen to tell the world about the "CAN-SPAM" Act passed by the US Congress in December, despite the nabobs of nerdish negativity who say it will do little to stem the tide of ads for dodgy degree certificates and under-the-counter drugs that clog our inboxes. So keen were they that they sent an editor of the webzine Light Reading a 1-megabyte photo-release of the president signing the act. And then another, equally unsolicited. Then four more. "Shouldn't there be a law against that kind of thing?" Light Reading asks.

THE new QuintrixSR television picture tube from Panasonic "uses an innovative shadow mask to reproduce pictures accurately and in great detail," it says in the Comet catalogue, before helpfully explaining that "A shadow mask is a perforated etched metal sheet that filters the red, green and blue coloured electrons into the correct position on the screen."

Don't they know that it's quarks that have colour, not electrons? Coming soon to a patent office near you: the proton-powered TV with filters for charm and strangeness. Please...

ACADEMIC publishing moves at a gentler pace than that of, say, weekly news magazines – even when it's not the *Journal of Glaciology*. So staff at one journal that shall remain nameless were pleased to have proofs of an article returned exactly on the deadline they had specified, conscientiously marked up to correct all the errors. The sender had even gone to the trouble of rewriting phrases to clarify previously opaque meanings.

This seemed all the more admirable in the light of the cover note: "I have done what you asked me to," it read, "but it is not clear why you sent this paper to me as I am not its author."

THE Gadget Shop website had this to say about its Tivoli "portable audio laboratory": "You also save money and help protect the environment because inside the PAL there's an environmentally friendly rechargeable Nicked Meal Hydride battery pack that gives up to 20 hours of playback from one charge."

Reader Mike Allin emailed the site to say, "I'm particularly intrigued to find out more about the 'Nicked Meal Hydride' batteries." Back came a message from the Gadget Shop customer services manager: "Dear Mike, Thank you for your email message, and thank you for spotting our typing error. This should read Nicked Metal Hydride Battery. This is now being amended."

The only question remaining in Allin's mind is: where do they nick the metal from? Church roofs?

MEANWHILE, speaking of gadgets, some refreshing honesty in marketing. Stuck for a gift for the man-boy in your life? Go to www.seethru.co.uk/shop/him and you will find: "for him – lots of black boxes with buttons and flashing LEDs on them". Click further and you find "technology – gadgets, computers, black boxes, stuff you don't need basically". "This section will be launching week December 11th," it claimed – and still did when we last looked, more than a month later.

OUR colleagues have always suspected us to be at a slight angle to the rest of the universe. Now we have confirmation, in the shape of our very own time zone. Just visit nist.time.gov/timezone.cgi?Feedback to see what time it is for us right now. Thanks to Fergal Dalton, who pointed us to this. Dalton also inhabits his own time zone (nist.time.gov/timezone.cgi?Fergal_Dalton) and is slightly concerned that the US National Institute of Standards and Technology knows so much about him.

Spotted in the west of England, at the Exeter branch of Lakeland Plastics: "Please queue at ALL open tills". Reader James Annear wonders whether quantum superposition will have to be called into play to achieve this

TRAINEES exist, like grad students, to be exploited. But we fear that the British Council, that body charged with spreading love for things British around the world, is being a bit too blatant about it. Its application form for the catchily named International Association for the Exchange of Students for Technical Experience asks, very reasonably, "How many hours per day would you expect your trainee to work," then clarifies helpfully: "minimum of 30 hours".

FINALLY, if you are travelling in or to the US, be careful what reading material you pack. On 24 December the FBI warned 18,000 police organisations to watch out for people carrying...almanacs.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

The last word

Last Words past and present, plus a full list of unanswered questions, are available on New Scientist's website at www.newscientist.com

CONCRETE JUNGLE

How much of the surface area of the UK is taken up by roads?

● The area of the hard surface of roads is difficult to estimate precisely because they are so narrow in comparison with the rest of the area in which they sit, and have a very small level of resolution on a map. I don't have figures for the UK, but a study by Anne Worrell and myself using point intercept on high-resolution photographs taken from the air gave the following estimates for Greater London: roads 8.5 per cent, footpaths and pavements 3.7 per cent and car parks 5.1 per cent. Each of these figures has a standard error of less than 1 per cent. Interestingly, the amount of land devoted to road travel in London is greater than any other single category of land use, except for suburban gardens, which take up 19.3 per cent. The figures for the UK as a whole must be very much lower, given that London is largely suburban and so has an extensive road network.

Dave Dawson

Greater London Authority biodiversity strategy manager, UK

● The short answer is that the concrete jungle of roads covers less than 1 per cent of the UK's surface area. The small size of this amount is particularly apparent when our green and pleasant land is seen from the air.

The internet community called SABRE (Society for All British Road Enthusiasts) has been hard at work to arrive at this figure. Our best estimate, derived from various and sometimes conflicting government data, is that there are 425,121 kilometres of public roads, comprising 3589 km of motorways, 56,696 km of A-roads (of which 7921 km are dual carriageway), 32,850 km of B-roads, 89,686 km of C-roads and 242,300 km of unclassified roads.

Allowing average paved widths of 26 metres for motorways, 18 metres for dual carriageways, 12 metres for other trunk roads, 8 metres for B-roads, 4 metres for C-roads and 3 metres for unclassified roads, gives a total area of almost 2200 square kilometres of road. The total area of the UK is usually given as 241,590 square kilometres, so about 0.9 per cent of the land area is road. A rather higher figure, about 1.3 per cent, is sometimes proposed if the total width of land occupied by roads, including verges and hedgerows, is included. This is a less appropriate measure because road verges contribute significantly to wildlife habitat and biodiversity, and cannot seriously be called roads.

More detailed statistics can be found in the discussion on the SABRE message boards under the thread "road surface area" at http://groups.msn.com/TheSABRERoadsWebsite

Biff Vernon

Management committee member of SABRE,

Louth, Lincolnshire, UK

● According to *Road Traffic Statistics for Great Britain: 2002*, published by the Department for Transport, "The total land area covered by all roads in Great Britain in 2001 was 3300 square kilometres." This represents about 1.4 per cent of the total land area. The report is available from www.dft.gov.uk/stellent/groups/dft_transstats/documents/page/dft_transstats_023319.hcsp.

Tim Lovell

Bristol, UK

● The Department for Transport figure given in Tim Lovell's answer includes verges and hedges, which is why this figure is similar to the higher figure given by Biff Vernon – Ed

ABREAST OF THE ISSUE

On regular walks in a South Derbyshire opencast coal mine a few years ago, I frequently found stones that looked remarkably like human breasts, even down to their colouring. These were in stony layers usually a couple of inches thick, like a cobbled surface. The stones varied in size from a couple of centimetres to about half-a-metre in diameter. I've used them as paperweights for some time – and naturally they attract comments. But what are they, and how did they form?

● Without further information on the properties of the stone, such as its hardness or grain structure, it is difficult to say. But I do have a theory.

I lived in Swadlincote, Derbyshire, and can remember no opencast coal mines. But there were numerous opencast clay pits, which provided clay for the local pottery industry.

As a schoolboy I worked in several potteries on Saturdays to earn pocket money, and one task was to feed the blunger. This machine mixed clay and water to produce slip – semi-liquid clay – that was put into plaster-of-Paris moulds to produce shapes.

The slip was often piped around the pottery. If a pipe leaked, then a "breast" of drying clay would form under the leak. It would not surprise me if some of these were placed in a kiln by jokers (perhaps even by me) for later amusement. Even in slip form they would be very durable.

Richard Birks

By email, no address supplied

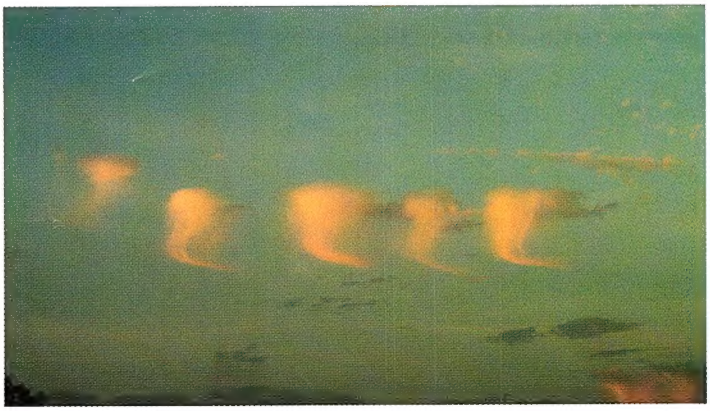
● This may be the answer, but there could still be other explanations. Pictures of the "stone breasts" can be seen on our website for those who might have further theories: www.newscientist.com/lastword/article.jsp?id=lw1075 – Ed

THIS WEEK'S QUESTION

Genius of the lamps?

On a September evening last year, my husband took this photograph (below) outside the front of our house in Cambridge looking east. The clouds seem to have come out of Aladdin's lamp. Can someone explain how such a remarkable pattern can be formed, or is the genie's tale true?

Omara Williams, Cambridge, UK



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EH/15/NS

PEOPLE DO NOT DECIDE TO BECOME EXTRAORDINARY.
THEY DECIDE TO ACCOMPLISH
EXTRAORDINARY THINGS.

On May 29, 1953 at 11:30 a.m., Sir Edmund Hillary and Sherpa Tenzing Norgay became the first men to stand on the summit of Mt. Everest. But the top of the mountain was just the beginning of Sir Edmund's journey. Fifty years later, his perpetual pursuit of things once imagined has resulted in the construction of 27 schools, two hospitals, medical clinics, bridges and freshwater pipelines for the people of Nepal. He may have left his footprint on a mountain, but he put his indelible imprint on the world. Proving once again that some people are just destined to rise to the top.

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